ARTICLE VIII.—*On the Food Relations of Fresh-Water Fishes: a Summary and Discussion.*—By S. A. FORBES.

The principal object of the research reported in the series of papers* of which this is the concluding number, is to determine more precisely than has hitherto been done the relations to nature of the various genera and families of the fishes of an interior region. This purpose has led especially to a study of the *food relations* of the groups, for through these, chiefly, fishes exert their influence on the outer world, and are themselves impressed in turn; and thus have appeared a number of subordinate considerations having a bearing, more or less direct, on the main intention of the study.

An examination of the special relations of their food and feeding structures gives us clues, not only to the present significance of fishes, but also to their past effect on life at large, showing how they must have modified the course of evolution; and the occasional occurrence in a fish of food prehensile structures out of present relation to its feeding habits, may throw light on the history of its group, indicating conditions of existence once normal to it but now outgrown. Evidence of similar application may also be obtained by a comparison of the food of the young and of the adult.

The feeding apparatus exhibits some of the most significant examples of correlation of structure, important to an acquaintance with the course of development in fishes, but not comprehensible without a knowledge of the food for whose appropria-

* Published at intervals from 1877 to 1888, in the first and second volumes of the Bulletin of this Laboratory, as follows: "The Food of Illinois Fishes" (Vol. I., No. 2, pp. 71–89), "The Food of Fishes" (No. 3, pp. 18–65), "On the Food of Young Fishes" (No. 3, pp. 66–79), "The Food of the Smaller Fresh-Water Fishes" (No. 6, pp. 65–94), The First Food of the Common White-fish, (No. 6, pp. 95–109), and "Studies of the Food of Fresh-Water Fishes" (Vol II., Art. VII., pp. 433–473).

tion it is adapted. I need hardly recall the fact that the defensive apparatus of one species may have its explanation only in the raptatorial structures of another.

We shall find also in a study of the food evidence of the indirect but powerful action of a number of external conditions which take effect only through the food relation, and are incomprehensible or perhaps unnoticed unless this is understood —conditions of climate, season, locality, and the like; and especially may we hope for this when we remember that the distribution and abundance of a species may be determined, not so much by ordinary conditions, as by those prevailing at critical intervals, periods of stress, when a slight advantage or a trivial disability may have prolonged and multiplied effects. As the range of a plant is often limited, not by the average temperature of the year, but by the extremes of cold or heat, so the existence of an animal may be decided by the presence or absence of some structural modification adapted to carry it safely through a single brief period of unusual scarcity or of extraordinary competition.

That the study here set forth should give us details not to be otherwise obtained of the struggle for existence among fishes themselves, goes without saying; and that it may thus explain some peculiarities of distribution, seems also probable. I have thought it not impossible that by taking into account all the data collected, and the mass of related facts, structural, biological, and other, that materials might be found bearing on the interesting question of the precedence in time and the relative evolutionary importance of desire and effort on the one hand and structural aptitudes on the other.

Among the purely practical results to be anticipated, are a more accurate knowledge of the conditions favorable to the growth and multiplication of the more important species; the ability to judge intelligently of the fitness of any body of water to sustain a greater number or a more profitable assemblage of fishes than those occurring there spontaneously; guidance as to the new elements of food and circumstance which it will be necessary to supply to insure the successful introduction into any lake or stream of a fish not native there; and a clear recognition of the fact that intelligent fish culture must take into

account the necessities of the species whose increase is desired, through all ages and all stages of their growth, at every season of the year, and under all varieties of condition likely to arise. We should derive, in short, from these and similar researches, a body of full, precise, and significant knowledge to take the place of the guess-work and empiricism upon which we must otherwise depend as the basis of our efforts to maintain the supply of food and the incitement to healthful recreation afforded by the waters of the State.

As a contribution to the general subject, I present herewith a summary account of the food of twelve hundred and twenty-one fishes obtained from the waters of Illinois at intervals from 1876 to 1887, and in various months from April to November. These fishes belonged to eighty-seven species of sixty-three genera and twenty-five families. They were derived from waters of every description, ranging from Lake Michigan to weedy stagnant ponds and temporary pools, and from the Mississippi and Ohio Rivers to the muddy prairie creeks, and the rocky rivulets of the hilly portions of the State. Nine hundred and fourteen of the examples studied were practically adult, so far as the purposes of this investigation are concerned, the remaining three hundred and seven being young, in the first stage of their food and feeding habits. More than half these young belonged to a single species,— the common lake whitefish,—but the remainder were well distributed.

I have arranged the matter under the following general heads: (1) a summary statement of the food, so made as to exhibit (*a*) the kinds and relative importance of the principal competitions among fishes and (*b*) the relative value to the principal species of fishes of the major elements of their food; (2) a brief account of the food of the young; (3) an examination of the permanency and definiteness of distinctions with respect to food, between different species, and also between higher groups; (4) a review of the structures of fishes related to food prehension and to their feeding habits; and, finally, (5) a classified list of the objects detected in the food of fishes, with a statement, against each object, of the species feeding on it and the number of specimens in which it was found.

THE FOOD OF ADULT FISHES.

An analysis of our facts made with reference to the kinds of fishes eating each of the principal articles in the dietary of the class and showing the relative importance of these elements in the food of the various species, will exhibit the competitions of fishes for food more clearly and precisely than my earlier discussions, and also the nature and the energy of the restraints imposed by fishes on the multiplication of their principal food species.

PISCIVOROUS FISHES.

The principal fish-eaters among our species — those whose average food in the adult stage consists of seventy-five per cent. or more of fishes — are the burbot[1], the pike-perch[2] or wall-eyed pike, the common pike[3] or "pickerel," the large-mouthed black bass,[4] the channel cat,[5] the mud cat,[6] and the gars.[7] Possibly also the golden shad[8] will be found strictly ichthyophagous, this being the case with the four specimens which I studied.

Those which take fishes in moderate amount — the ratios ranging in my specimens from twenty-five to sixty-five per cent. — are the war-mouth (Chænobryttus), the blue-cheeked sunfish,[9] the grass pickerel,[10] the dog-fish,[11] the spotted cat,[12] and the small miller's thumb[13]. The white[14] and striped bass,[15] the common perch,[16] the remaining sunfishes (those with smaller mouths), the rock bass,[17] and the croppie,[18] take but few fishes, these making, according to my observations, not less than five nor more than twenty-five per cent. of their food.

Those which capture living fishes, to a trivial extent, at most, are the white perch or sheepshead,[19] the gizzard

[1] Lota maculosa. [2] Stizostedion vitreum. [3] Esox lucius. [4] Micropterus salmoides. [5] Ictalurus furcatus. [6] Leptops olivaris. [7] Lepidosteus. [8] Clupea chrysochloris. [9] Lepomis cyanellus. [10] Esox vermiculatus. [11] Amia calva. [12] Ictalurus punctatus. [13] Uranidea richardsonii. [14] Roccus chrysops. [15] Roccus interruptus. [16] Perca lutea. [17] Ambloplites rupestris. [18] Pomoxys. [19] Aplodinotus.

shad,[1] the suckers,[2] and the shovel fish[3] among the larger species; the darters,[4] the brook silversides,[5] the stickleback,[6] the mud minnows,[7] the top minnows,[8] the stonecats,[9] and the common minnows[10] generally, among the smaller kinds.

Our eight specimens of the toothed herring[11] had taken no fishes whatever; while our nineteen examples of the pirate perch[12] had eaten only two per cent.

Rough-scaled fishes with spiny fins (Acanthopteri) were eaten by the miller's thumb, the common pike, the wall-eyed pike, the large-mouthed black bass, the croppies, the dog-fish, the common perch, the burbot, the bull-head,[13] the common sunfish (*Lepomis pallidus*), the small-mouthed black bass,[14] the grass pickerel, the gar, and the mud cat (Leptops). Among these, the common perch and the sunfishes[15] were most frequently taken — doubtless owing to their greater relative abundance — the perch occuring in the food of the burbot, the large-mouthed black bass, and the bull-head; and sunfishes in both species of the wall-eyed pike, the common pike, the gars, pickerel, bull-heads, and mud cat. Black bass were taken from the common pike (Esox), the wall-eyed pike (Stizostedion), and the gar. Croppie and rock bass I recognized only in the pike. Even the catfishes (Siluridæ) with their stout, sharp, and poisoned spines, were more frequently eaten than would be expected,— taken, according to my notes, by the wall-eyed pike, both black bass, and the mud-cat (the latter a fellow species of the family).

The soft-finned fishes were not very much more abundant, on the whole, in the stomachs of other species than were those with ctenoid scales, spiny fins, and other defensive structures,— an unexpected circumstance which I cannot at present explain, because I do not know whether it expresses a normal and fixed relation, or whether it may not be due to human interference. It will be shown, however, under another head, that even when the primitive order of nature prevails, the relative numbers of soft-finned and predaceous fishes vary greatly from year to year under the influence of varying circumstances.

[1] Dorosoma cepedianum. [2] Catostomatidæ. [3] Polyodon spathula. [4] Etheostomatinæ. [5] Labidesthes sicculus. [6] Eucalia inconstans. [7] Umbra limi. [8] Zygonectes. [9] Noturus. [10] Cyprinidæ. [11] Hyodon tergisus. [12] Aphredoderus sayanus. [13] Amiurus nebulosus. [14] Micropterus dolomiei. [15] Centrarchidæ.

Only the catfishes seem to have acquired defensive structures equal to their protection, the predatory apparatus of the carnivorous fishes having elsewhere outrun in development the protective equipment of the best-defended species.

Among the soft-finned fishes the most valuable as food for other kinds is the gizzard shad (Dorosoma),— this single fish being about twice as common in adults as all the minnow family taken together. It made forty per cent. of the food of the wall-eyed pike; a third that of the black bass; nearly half that of the common pike or "pickerel"; two thirds that of the four specimens of golden shad examined; and a third of the food of the gars. The only other fishes in whose stomachs it was recognized were the yellow cat *(Amiurus natalis)* and the young white bass *(Roccus)*. It thus seems to be the especial food of the large game fishes and other particularly predaceous kinds.

The minnow family (Cyprinidæ) are in our waters especially appropriated to the support of half-grown game fishes, and the smaller carnivorous species. They were found in the wall-eyed pike, the perch, the black bass, the blue-cheeked sunfish, the croppie, the pirate perch, the pike, the little pickerel,[1] the chub minnow,[2] the yellow cat, the mud cat, the dog-fish, and the gar.

Suckers (Catostomatidæ) I determined only from the pike, the sheepshead, the blue-cheeked sunfish, the yellow cat, and the dog-fish (Amia). Buffalo[3] and carp[4] occurred in the pike, the dog-fish, and the above sunfish.

MOLLUSK EATERS.

The ponds and muddy streams of the Mississippi Valley are the native home of mollusks in remarkable variety and number, and these form a feature of the fauna of the region not less conspicuous and important than its characteristic and leading groups of fishes. We might, therefore, reasonably expect to find these dominant groups connected by the food relation; and consistently with this expectation, we observe that the sheepshead, the cat-fishes, the suckers, and the dog-fish find an impor-

[1] Esox vermiculatus. [2] Semotilus. [3] Ictiobus. [4] Carpiodes.

tant part of their food in the molluscan forms abundant in the waters which they themselves most frequent. The class as a whole makes about one fourth of the food of the dog-fish and the sheepshead,— taking the latter as they come, half-grown and adults together,—about half that of the cylindrical suckers,—rising to sixty per cent. in the red horse,[1]— and a considerable ratio (fourteen to sixteen per cent.) of the food of the perch, the common catfishes (Amiurus and Ictalurus). the small-mouthed sunfishes, the top minnows, and the shiner (Notemigonus). Notwithstanding the abundance of the fresh water clams or river mussels (Unio and Anodonta), only a single river fish is especially adapted to their destruction, viz., the white perch or sheepshead; and this species derives, on the whole, a larger part of its food from univalve than from bivalve mollusks, the former being eaten especially by half-grown specimens, and the latter being the chief dependence of the adults.

The ability of the catfishes to tear the less powerful clams from their shells has been especially discussed in another paper* containing the details of the food of the family. Even the very young Unios were rarely encountered in the food of fishes, my notes recording their presence in only three sunfishes, a brook silversides, and a perch. Large clams were eaten freely by the full-grown sheepshead — whose enormous and powerful pharyngeal jaws with their solid pavement teeth are adapted to crushing the shells of mollusks — and by the bull-heads (Amiurus), especially the marbled cat.[2] The small and thin-shelled Sphæriums are much more frequent objects in the food of mollusk-eating fishes than are the Unios. This genus alone made twenty-nine per cent. of the food of our one hundred and seven specimens of the sucker family, and nineteen per cent. of that of a dozen dog-fishes. Among the suckers it was eaten greedily by both the cylindrical and the deep-bodied species, although somewhat more freely by the former. Even the river carp,[3] with its weak pharyngeal jaws and delicate teeth, finds these sufficient to crush the shells of Sphærium, and our nineteen specimens had obtained about

* Bull. Ill. St. Lab. Nat. Hist., Vol. II., pp. 457, 458.

[1] Moxostoma. [2] Amiurus marmoratus. [3] Carpiodes.

one fourth of their food from this genus. Besides the above families, smaller quantities of the bivalve mollusks occurred in the food of one of the sunfishes *(Lepomis pallidus)* and — doubtless by accident only — in the gizzard shad.

The gasteropod mollusks (snails of various descriptions) were more abundant than bivalve forms in the sheepshead and the sunfishes and all the smaller fishes which feed upon Mollusca, but less abundant in the suckers and the catfishes. In the sheepshead they made one fifth of the food of the twenty-five specimens examined, but the greater part of these had not yet passed the insectivorous stage, this being much longer continued in the sheepshead than in many other fishes. A few of these univalve Mollusca occurred in the food of the common perch and in certain species of sunfishes, especially in the superabundant bream or pumpkin-seed. They made fifteen per cent. of the food of the minute top minnows, and occurred in smaller quantities among the darters, the grass pickerel, the mud minnows, and the cyprinoids. The heavier river snails, Vivipara and Melantho, were eaten especially by the cylindrical suckers, and the catfishes. The delicate pond snails (Succinea, Limnæa, and Physa) were taken chiefly by the smaller mollusk-eating fishes,— a few of them also by the catfishes and the suckers.

Further particulars concerning the molluscan food may be obtained by the interested reader from the list of food elements at the end of this article.

INSECTIVOROUS SPECIES.

It is from the class of insects that adult fishes derive the most important portion of their food, this class furnishing, for example, forty per cent. of the food of all the adults which I examined.

The principal insectivorous fishes are the smaller species, whose size and food structures, when adult, unfit them for the capture of Entomostraca, and yet do not bring them within reach of fishes or Mollusca. Some of these fishes have peculiar habits which render them especially dependent upon insect life,— the little minnow Phenacobius, for example, which, according to my studies, makes nearly all its food from insects (ninety-eight per cent.) found under stones in running

water. Next are the pirate perch, Aphredoderus (ninety-one per cent.), then the darters (eighty-seven per cent.), the croppies (seventy-three per cent.), half-grown sheepshead (seventy-one per cent.), the shovel fish (fifty-nine per cent.), the chub minnow (fifty-six per cent.), the black warrior sunfish (Chænobryttus) and the brook silversides (each fifty-four per cent.), and the rock bass and the cyprinoid genus Notropis, (each fifty-two per cent.)

Those which take few insects or none are mostly the mud-feeders and the ichthyophagous species, Amia (the dog-fish) being the only exception noted to this general statement. Thus we find insects wholly or nearly absent from the adult dietary of the burbot, the pike, the gar, the black bass, the wall-eyed pike, and the great river catfish, and from that of the hickory shad[1] and the mud-eating minnows (the shiner, the fat-head,[2] etc.). It is to be noted, however, that the larger fishes all go through an insectivorous stage, whether their food when adult be almost wholly other fishes, as with the gar and the pike, or mollusks, as with the sheepshead. The mud-feeders, however, seem not to pass through this stage, but to adopt the limophagous habit as soon as they cease to depend upon Entomostraca.

Terrestrial insects, dropping into the water accidentally or swept in by rains, are evidently diligently sought and largely depended upon by several species, such as the pirate perch, the brook minnow, the top minnows or killifishes (cyprinodonts), the toothed herring and several cyprinoids (Semotilus, Pimephales, and Notropis).

Among aquatic insects, minute slender dipterous larvæ, belonging mostly to Chironomus, Corethra, and allied genera, are of remarkable importance, making, in fact, nearly one tenth of the food of all the fishes studied. They are most abundant in Phenacobius and Etheostoma, which genera have become especially adapted to the search for these insect forms in shallow rocky streams. Next I found them most generally in the pirate perch, the brook silversides, and the stickleback, in which they averaged forty-five per cent. They amounted to about one third the food of fishes as large and important as the red

[1] Dorosoma. [2] Pimephales.

horse and the river carp, and made nearly one fourth that of fifty-one buffalo fishes. They appear further in considerable quantity in the food of a number of the minnow family (Notropis, Pimephales, etc.), which habitually frequent the swift water of stony streams, but were curiously deficient in the small collection of miller's thumbs (Cottidæ) which hunt for food in similar situations. The sunfishes eat but few of this important group, the average of the family being only six per cent.

Larvæ of aquatic beetles, notwithstanding the abundance of some of the forms, occurred in only insignificant ratios, but were taken by fifty-six specimens, belonging to nineteen of the species,— more frequently by the sunfishes than by any other group. The kinds most commonly captured were larvæ of Gyrinidæ and Hydrophilidæ; whereas the adult surface beetles themselves (Gyrinus, Dineutes, etc.) — whose zigzag-darting swarms no one can have failed to notice — were not once encountered in my studies.

The almost equally well-known slender water-skippers (Hygrotrechus) seem also completely protected by their habits and activity from capture by fishes, only a single specimen occurring in the food of all my specimens. Indeed, the true water bugs (Hemiptera) were generally rare, with the exception of the small soft-bodied genus, Corisa, which was taken by one hundred and ten specimens, belonging to twenty-seven species, — most abundantly by the sunfishes and top minnows.

From the order Neuroptera fishes draw a larger part of their food than from any other single group. In fact, nearly a fifth of the entire amount of food consumed by all the adult fishes examined by me consisted of aquatic larvæ of this order, the greater part of them larvæ of day flies (Ephemeridæ), principally of the genus Hexagenia.* These neuropterous larvæ were eaten especially by the miller's thumb, the sheepshead, the white and striped bass, the common perch, thirteen species of the darters, both the black bass, seven of the sunfishes, the rock bass and the croppies, the pirate perch, the brook silversides, the sticklebacks, the mud minnow, the top min-

* The winged adults of this and related genera are often called "river flies" in Illinois.

nows, the gizzard shad, the toothed herring, twelve species each of the true minnow family and of the suckers and buffalo, five catfishes, the dog-fish, and the shovel fish,—seventy species out of the eighty-seven which I have studied.

Among the above, I found them the most important food of the white bass, the toothed herring,the shovel fish (fifty-one per cent.), and the croppies; while they made a fourth or more of the alimentary contents of the sheepshead (forty-six per cent.), the darters, the pirate perch, the common sunfishes (Lepomis and Chænobryttus), the rock bass, the little pickerel, and the common sucker (thirty-six per cent).

Ephemerid larvæ were eaten by two hundred and thirteen specimens of forty-eight species — not counting young. The larvæ of Hexagenia, one of the commonest of the "river flies," was by far the most important insect of this group, this alone amounting to about half of all the Neuroptera eaten. They made nearly one half of the food of the shovel fish, more than one tenth that of the sunfishes, and the principal food resource of half-grown sheepshead; but were rarely taken by the sucker family, and made only five per cent. of the food of the catfish group.

The various larvæ of the dragon flies, on the other hand, were much less frequently encountered. They seemed to be most abundant in the food of the grass pickerel, (twenty-five per cent.), and next to that, in the croppie, the pirate perch, and the common perch (ten to thirteen per cent.).

Case-worms (Phryganeidæ) were somewhat rarely found, rising to fifteen per cent. in the rock bass and twelve per cent. in the minnows of the Hybopsis group, but otherwise averaging from one to six per cent. in less than half of the species.

THE CRUSTACEAN ELEMENT.

Of the four principal classes of the animal food of fishes; viz., fishes, mollusks, insects, and Crustacea, the latter stand third in importance according to my observations, mollusks alone being inferior to them. That insect larvæ should be more abundant in the food of fresh-water fishes than are crustaceans, is a somewhat unexpected fact, but while the former made about

twenty-five per cent. of the food of our entire collection, the crustaceans amounted to only fourteen per cent. These divide conveniently into crayfishes, the medium-sized, sessile-eyed crustaceans (Isopoda and Amphipoda), and Entomostraca. The so-called fresh-water shrimps (Palæmon and Palæmonetes) appeared so rarely in the food that they need scarcely be taken into the account.

Crayfishes made about a sixth of the food of the burbot; about a tenth that of the common perch, a fourth that of half a dozen gars, not far from a third that of the black bass,* the dog-fish, and our four rock bass. Young crayfishes appeared quite frequently in some of the larger minnows (Semotilus and Hybopsis), and also in catfishes, especially the pond and river bull-heads, averaging nearly fifteen per cent. of the entire food of the two most abundant species.

The small, sessile-eyed crustaceans eaten by fishes were nearly all of four species; viz., *Allorchestes dentata*,— excessively abundant in the northern part of the State,— a species of Gammarus not uncommon in running streams, and two representatives of the isopod genera Asellus and Mancasellus. To fishes at large, this group is of little importance; but the perch of northern Illinois finds about one third of its food among them, and the common sunfishes (Lepomis) eat a considerable ratio (eleven per cent.). The miller's thumb of southern Illinois seems also to search for them among the stones.

The little Allorchestes mentioned above I found in a single white bass, in eleven of the common perch, in one of the largest darters, in five young black bass, in seventeen sunfishes of various species, in the rock bass, the pirate perch, a single grass pickerel and six top minnows, in only two of the true minnow family, in two only of the sucker tribe, in seventeen catfishes,— mostly young or of the smallest species,— in a single dog-fish, and in a single spoon-bill.[1] The common

* Our specimens — especially of the small-mouthed black bass — were too few in number to make this average reliable.

[1] Polyodon.

Asellus, or water wood louse, was less generally eaten; by only two of the miller's thumb, a single sheepshead, a white bass, four perch, two young black bass, eight sunfishes (Lepomis), two pirate perch, a grass pickerel, three small catfishes, and a dog-fish.

The minute crustaceans commonly grouped as Entomostraca are a much more important element. Among full-grown fishes, I find them especially important in the shovel fish,— where they made one third the food of the specimens studied, — in the common lake herring,[1] in the brook silversides (forty per cent.), in the stickleback (thirty per cent.), in the darter family (eleven per cent.), and in the mud minnows (ten per cent.). The perch had taken scarcely a trace of them. Among the sunfishes at large they were present in only insignificant ratio; but two genera (Pomoxys and Centrarchus), distinguished by long and numerous rakers on the anterior gill, had derived about one tenth of their food from these minute crustaceans. In the early spring especially, when the backwaters of the streams are filled with Entomostraca, the stomachs of these fishes are often distended with the commonest forms of Cladocera.

Notemigonus and Notropis among the minnows, represented in my collections by one hundred and twenty-five and one hundred specimens respectively, had obtained about a sixth of their food from Entomostraca.

Ten per cent. of the food of the sucker family consisted of them, mostly taken by the deep-bodied species Carpiodes and Ictiobus, in which they made a fourth or a fifth of the entire food. This fact is explained, it will be remembered, by the relatively long, slender, and numerous gill-rakers of these fishes. Large river-buffalo were occasionally crammed with the smallest of these Entomostraca,— the minute Canthocamptus, only a twenty-fifth of an inch in length.

I have several times remarked the peculiar importance of Entomostraca to the shovel fish,— one of the largest of our fresh-water animals,— a fact accounted for by the remarkable branchial strainer of this species, probably the most efficient apparatus of its kind known to the ichthyologist. Here,

[1] Coregonus artedi.

again, the smallest forms were the most abundant. Generally, however, the Cladocera were more common than the other orders, the bivalve Cypris (most frequent in the mud) being much less abundant in the food. I have shown elsewhere,* at length, that Entomostraca compose by far the greater part of the food of young fishes of all descriptions,— with the partial exception of the sucker family, the young of which feed largely on still more minute organic forms,— and present an abstract of these facts in this article under another head.†

Particulars concerning the use of this abundant and varied group as food for fishes, are so numerous as to make them difficult to summarize, and the interested reader is again referred to the detailed list accompanying this paper.

VERMES AS FOOD FOR FISHES.

Probably to those accustomed to the abundance of true worms (Vermes) in marine situations, no feature of the poverty of fresh-water life will be more striking than the small number of this subkingdom occurring in the course of miscellaneous aquatic collections in the interior. Similarly we notice that in the food of fishes the occurrence of Vermes is so rarely noticed that they might be left out of account entirely without appreciably affecting any of the important ratios.

The minnows (cyprinoids) had eaten more of them than any other family,— three per cent. of the food of twenty-two specimens of Semotilus being credited to them, and one per cent. of that of thirteen specimens of Pimephales, besides a trace in the food of Notropis. More precisely analyzed, we find that a single Nais, a Lumbriculus, two examples of Gordius (doubtless taken as insect parasites) and several minute rotifers (wheel-animalcules) are the forms upon which this estimate is based.

A trace of Vermes likewise appears in the food of suckers, — mostly a polyzoan species (Plumatella) and minute rotifers sucked up with the mud.

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* Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 3, pp. 75, 76.

† See pp. 495 and 496.

Catfishes alone seem purposely to eat leeches, these occurring in nine specimens of three different species of this family, and also in one common sucker and in a single shovel fish. This leech last mentioned and a small quantity of Plumatella were the only Vermes eaten by the shovel fishes which I examined.

A planarian worm occurred in one small stone cat, while rotifers were recognized in a common minnow, eight young red-horse, six young chub suckers,[1] five of the common sucker,[2] a single Carpiodes (young), and seven young buffalo. Polyzoa were noted, in addition to the instances above mentioned, in four common sunfishes, the croppie, and seven buffalo.

SPONGES AND PROTOZOA.

One of the fresh water sponges (Spongilla) had been eaten in considerable quantities by two examples of the spotted cat taken in September, but this element was not encountered elsewhere in my studies.

That the minutest and simplest of all the animal forms, far too small for the eye of a fish to see without a microscope, should have been recognized in the food of seventeen species of fishes is, of course, to be explained only as an incident of the feeding habit. It is possible, however, that these Protozoa, where especially abundant, may be recognized in the mass by the delicate sensory structures of the fish; and they seem in most cases to have been taken with mud and slime rich in organic substances, As most of them are extremely perishable, and can scarcely leave a trace a few seconds after immersion in the gastric juices of the fish, it is probable that they contribute much more generally than our observations indicate to the food of some fishes, especially to those which feed upon the bottom.

Young suckers under six inches in length clearly take them purposely, substituting them in great part for the Entomostraca taken by other fishes of their size and age.

I detected Protozoa in the food of several genera of Cyprinidæ, in the young of buffalo, the river carp, the chub sucker, the red horse, the stone roller,[3] in the common sucker,

[1]Erimyzon sucetta. [2]Catostomus teres. [3]Hypentelium.

in a single gizzard shad, in a stone cat, and in a top minnow. The commonest forms, as would be supposed, were those protected by permanent shells; viz., Difflugia, Centropyxis, Arcella, and the like; but occasionally specimens of Actinosphærium, Euglena, and Dinobryon were present and recognized.

SCAVENGERS.

The only scavenger fishes of our collection were three species of the common catfishes; the spotted cat, the yellow cat, and the marbled cat,—all of which had eaten dead animal matter, including pieces of fish, ham, mice, kittens, and the like. A single large-mouthed black bass had likewise eaten food of this description.

VEGETABLE FEEDERS.

Considering the wealth of vegetation accessible to aquatic animals, and the fact that few other strictly aquatic kinds have the vegetarian habit, it is indeed remarkable that the plant food of fishes is an unimportant part of their diet. Taking our nine hundred specimens together, the vegetation eaten by them certainly would have amounted to less than ten per cent. of their entire food, and excluding vegetable objects apparently taken by chance, it probably would not reach five per cent.

The greatest vegetarians are among the minnow family, largely in the genera Hybopsis, Notemigonus, and Semotilus, thirteen specimens of the first and twenty-five of the second having taken about half their food from vegetable objects. One hundred and twelve Notropis, twenty-two Semotilus, eighteen Hybognathus, and nine Campostoma, had found in the vegetable kingdom a fourth or fifth of their food. Counting each genus as a unit, I find that the family as a whole obtained from plants about twenty-three per cent. of its food. The little Phenacobius, already reported as strictly insectivorous, was the only one studied in which vegetation can scarcely be said to occur.

The mud minnows (Umbridæ) are also largely vegetarian (forty-one per cent.); and likewise the cyprinodonts, the vegeta-

ble average in the food of thirty-three specimens being seventeen per cent. Plant structures made about one fourth the food of seven sticklebacks.

Certain of the sunfishes evidently take plant food purposely, on occasion, this making, for example, nearly a tenth of the food of forty-seven specimens of Lepomis. Among the larger fishes, the principal vegetarian is the gizzard shad, in which this element was reckoned at about a third,— taken, however, not separately, but with quantities of mud. A considerable part of it was distillery slops obtained near towns.

The buffalo fishes are likewise largely vegetarian, more than a fourth of their food coming from plants,—about a third of this in our specimens, refuse from distilleries. Vegetation made a tenth of the food of the larger genera of catfishes (Amiurus and Ictalurus),—some of it distillery refuse,— and nearly as large a ratio of that of the great Polyodon.

Not infrequently, terrestrial vegetable rubbish — seeds of grasses, leaves of plants, and similar matter — was taken in quantity to make it certain that its appropriation was not accidental.

Besides a great variety of Algæ, both filamentous and unicellular, including considerable quantities of diatoms, the principal plant forms found in the food of fishes were the duckweeds Lemna and Wolffia. The deep-bodied suckers, especially, occasionally take quantities of these little plants during the autumnal months.

MUD.

The principal mud-eating fishes are the gizzard shad, the common shiner, and the genera of minnows belonging to the groups with elongate intestines and cultrate pharyngeal teeth; viz., Pimephales, Hybognathus, Chrosomus, and Campostoma. Much mud was taken also by the cylindrical members of the sucker family, but apparently as an incident to their search for mollusks.

SUMMARY OF THE FOOD OF THE YOUNG.*

By an examination of three hundred and seven specimens, representing twenty-seven species, twenty-six genera, and twelve families of Illinois fishes, I learn that the food of many species differs greatly according to age, and that, in fact, the life of most of our fishes divides into at least two periods, and that of many into three, with respect to the kinds of food chiefly taken.

In the first of these periods a remarkable similarity of food was noticed among species whose later feeding habits are widely different. The full grown black bass, for example, feeds principally on fishes and crayfishes, the sheepshead on mollusks, and the gizzard shad on mud and Algæ, while the catfishes are nearly omnivorous; yet all these agree so closely in food when very small, that one could not possibly tell from the contents of the stomachs which group he was dealing with.

I will now summarize the facts concerning the earliest food of the principal species, taken *seriatim.*

The food of six common perch *(Perca lutea)* from an inch to an inch and a quarter long, consisted wholly of Entomostraca (ninety-two per cent.) and minute larvæ of Chironomus. No very small white bass (Labracidæ) were found, the youngest being an inch and a quarter long. Half the food of this consisted of Entomostraca, and the other half of minute gizzard shad. Forty-three sunfishes (Centrarchidæ) from five eighths of an inch to two inches long, had made ninety-six per cent. of their food of Entomostraca and the small larvæ of gnats (Chironomus) already mentioned, seventy per cent. of the first and twenty-six of the second. This group comprised five specimens of black bass under three quarters of an inch in length, two rock bass of similar size, two of the large-mouthed sunfish (Chænobryttus) from seven eighths of an inch to an inch long, nineteen of the commoner sunfishes (Lepomis) ranging in length from an inch to two inches, five of the genus Centrarchus, one inch and under, four croppies

* For detailed treatment of this topic see Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 3, p. 66, and No. 6, p. 95.

(Pomoxys) from three quarters of an inch to an inch and a half, and six indeterminable specimens, probably Lepomis, from seven sixteenths to five eighths of an inch long. A single sheepshead an inch and an eighth in length had eaten Chironomus larvæ (seventy-five per cent.) and larvæ of the "river fly" (Hexagenia). A single grass pickerel about an inch and a quarter long had taken about sixty per cent. of its food from Entomostraca and young Amphipoda, the remainder consisting of little fishes.

The first food of the common white-fish was determined experimentally, the breeding habits of this species making direct observation impossible. Three hundred and forty very young fry fed with fragments of the brook shrimp, Gammarus, in a hatching house, were examined in January, 1881, and thirty-five of them, which had apparently taken food, were dissected. Minute fragments of Gammarus were found in but eighteen of these, while five contained minute insect larvæ, four, Entomostraca, and eight, small particles of vegetation,—objects accidentally conveyed to them in the water of the hatching house. In two hundred and forty-two others, confined in spring water; only eight were found to have eaten anything, and these had taken only Algæ and vegetable fragments. In February of the same year, fourteen specimens, confined in a small aquarium and supplied with living objects, plant and animal, from stagnant pools, were proven to feed freely upon the smallest Entomostraca presented to them,—chiefly Cyclops and Canthocamptus, ten of the fourteen eating Cyclops, three Canthocamptus, and one a specimen of each.

A little later, a more extensive experiment was conducted by means of a large aquarium, in which there were placed several hundred fry, kept constantly supplied with all the living objects which a fine gauze net would separate from the waters of Lake Michigan. Of one hundred and six of these, dissected within the following fortnight, sixty-three had taken food consisting almost wholly of the smallest Entomostraca occurring in the Lake (a minute Cyclops and a slender Diaptomus). The other objects encountered were rotifers, and diatoms and other unicellular Algæ, appearing, however, in such trivial quantity as to contribute nothing of importance to the support of the fry.

A dozen specimens of small gizzard shad, ranging in length from four fifths of an inch to nearly two inches, had eaten about ninety per cent. of Entomostraca, two per cent. of Chironomus larvæ, and, for the remainder, Algæ.

The true minnows (Cyprinidæ) seem to agree with the suckers in the more minute character of their early food. Six examples — three eights to three fourths of an inch long — too small to determine, but apparently belonging to the genera Minnilus, had eaten Entomostraca, Chironomus larvæ, many Protozoa, and unicellular Algæ, a few filamentous Algæ and minute fungi and fungus spores, a water mite, and a few accidental insects. In several specimens of the common chub minnow (Semotilus), from five eighths of an inch to an inch in length, seven per cent. of the food was Entomostraca, and the remainder consisted of filamentous Algæ. It should be noted, however, that twenty per cent. of that of the smallest specimen, which was five eighths of an inch long, was Cyclops, and it may be that Semotilus lives wholly on Entomostraca at first, merely changing its habit earlier than most of its allies. Two other minnows of the genus Notropis, an inch and a half in length, had eaten nothing but Entomostraca. The Cyprinidæ, like the sucker family, are toothless when young.

Thirty young suckers were studied, representing five genera of their family. The very smallest were found feeding on Entomostraca only, and it is possible that these usually form the first food of the family; but later they resort to elements still more minute; viz., rotifers, Protozoa, and unicellular Algæ, quantities of which were found in the intestines of young suckers six inches or more in length. Young stone rollers (Hypentelium) not more than an inch and a half long, had taken chiefly larvæ of Chironomus (ninety per cent.), the remaining tenth being principally Entomostraca. A single small black sucker (Minytrema) had eaten little but Cyclops. Four chub suckers (Erimyzon), two three quarters of an inch, and two an inch and a quarter long, had eaten only Entomostraca and a trace of water mites. In two larger specimens, however, still minuter forms were the leading feature of the food, including rotifers, Protozoa, and unicellular Algæ. Another example, three inches long, had eaten a trace of

Chironomus larvæ, but for all the rest, one of the smallest of the Entomostraca (Canthocamptus). Ten young red horse (Moxostoma), varying in length from an inch to two and three fourths inches, had fed largely upon Protozoa,— especially the largest of the specimens,— but the smallest of them had taken a considerable amount of Entomostraca,—notably the bivalve cyprids occurring on the bottom. Two of the commonest buffalo fish (Ictiobus), seven eighths of an inch long, had eaten most freely of unicellular Algæ (sixty-three per cent.), the remainder of the food consisting of rotifers and Entomostraca. Four of the river carp (Carpiodes), seven eighths of an inch to two inches long, had fed like the preceding, except that the Entomostraca amounted to nearly half the food, while the rotifers were comparatively few.

Young catfishes, only three eighths of an inch in length, belonging to the genus Amiurus, but quite too small to be specifically determinable, were filled with various Entomostraca and Chironomus larvæ. Other examples of this genus, making thirteen in all, none longer than an inch and five eighths, had fed almost wholly on Entomostraca and larvæ of Chironomus, the latter, however, composing seventy-four per cent. of the food of all, and the former eighteen per cent. Six small stone cats (Noturus), varying in length from seven eighths of an inch to one and a half inches, had taken more Chironomus larvæ and scarcely any Entomostraca.

A single dog-fish (Amia), one and three fourths inches long, had eaten seventy per cent. of Entomostraca, a few larvæ of Chironomus, some small crustaceans, and aquatic insects. Others of the species, under an inch in length, had the intestine packed with Entomostraca. Of the common river gars one, an inch and a quarter long, had filled itself with minute Entomostraca, while two other specimens had eaten only the smallest fry of fishes.

To recapitulate, I find that, taking together the young of all the genera studied, considering each genus as a unit, and combining the minute dipterous larvæ with the Entomostraca as having essentially the same relation, about seventy-five per cent. of the food taken by young fishes of all descriptions is made up of these elements.

From the above it is clear that young fishes in general depend at first on Entomostraca and certain small insect larvæ (chiefly those of two genera of gnats), beginning with the smallest of these forms, or with those especially exposed to their attack. One-celled plants and animals are also eaten freely by the young of two of the largest families.

Correlated with these facts, I find that two at least of the genera, which are toothless when adult, have minute raptatorial teeth in this early stage; viz., Coregonus and Dorosoma. Otherwise young fishes have no apparatus specially adapted to the capture of their minute prey, but this is brought within their reach merely by their own small size and the corresponding minuteness of their structures of food prehension. Later, as the larger species grow, this apparatus becomes too coarse to retain objects so minute, but other food resources are made available, usually through some adaptive modification of the fishes themselves.

In other words, one-celled organisms and Entomostraca are the natural, and practically the only, food of an undifferentiated small fish; and to be at liberty to grow, the fish must either change its food (as is usually done) or must develop a special apparatus (commonly a set of fine long gill-rakers) for the separation of Entomostraca from the waters in which they swim.

Of the fishes which emerge from this earliest stage, through increase in size with failure to develop alimentary structures especially fitted to the appropriation of minute animal forms, some become mud-eaters, like Campostoma and the gizzard shad; a few apparently become vegetarians at once; but most pass into or through an insectivorous stage. After this a few become nearly omnivorous, like the bull-heads; others learn to depend chiefly on molluscan food, — the sheepshead and the red horse species, — but many become essentially carnivorous. In fact, unless the gars are an exception, as they now seem to be, (attacking young fishes almost as soon as they can swallow,) all our specially carnivorous fishes make a progress of three steps, marked, respectively by the predominance of Entomostraca, of insects, and of fishes, in their food; and the same is true of those strictly fitted for a molluscan diet.

While small fishes of all sorts are evidently competitors for food, this competition is relieved to some extent by differences of breeding season, the species dropping in successively to the banquet, some commencing in very early spring, or even, like the white-fish, depositing their eggs in fall, that their young may be the first at the board, while others delay until June or July. The most active breeding period coincides, however,with that of the greatest evolution of Entomostraca in the backwaters of our streams; that is, the early spring.

That large adult fishes, with fine and numerous rakers on the gills — like the shovel-fish and the river carp — may compete directly with the young of all other species, and tend to keep their numbers down by diminishing their food supply — especially in times of scarcity — is very probable, but is not certainly true; for these larger fishes have other food resources also, and may resort to Entomostraca only when these are superabundant, thus appropriating the mere excess above what are required for the young of other groups.

ON THE DEFINITENESS AND PERMANENCY OF THE FOOD HABITS OF FISHES.

It is always posssible that the seemingly specific differences of food exhibited by data derived from miscellaneous collections not strictly comparable as to dates and localities, are really due to differences of circumstance affecting the representatives of the species, and not to differences in the food habits or the regimen of the species in general. Date, locality, and other circumstantial conditions, may have more to do with the distinctions of food detected than structure and specific habit. It is true that the probability of such errors of inference is reduced to a minimum where alimentary peculiarities can be clearly correlated with peculiarities of structure, as has usually been done in my discussions; but to test still further the distinctness of species and genera with respect to food habits and preferences, I have assorted my observations according to dates and localities of the collections on which they were made and have compared species with species as occurring under the

same general conditions and at the same time. If perch and catfishes caught in the same haul of the seine show more marked differences in food between the two groups than those exhibited by the individuals of each group among themselves, the probability is considerable that the differences are specific instead of accidental; and such probability becomes greater the greater the number of species found to present corresponding differences under corresponding circumstances. Although it was rarely the case that examples enough of two or more species comparable as to size and range had been taken at the same time and place to afford a tolerable average of the food under local conditions, yet a sufficient number of such cases was found to give a considerable amount of evidence on this point.

Thus three specimens of the marbled cat, *Amiurus marmoratus*, taken at Peoria, Nov. 1, 1878, had derived nine tenths of their food from Hexagenia larvæ, the remainder consisting of leeches and a few spiders; while eight specimens of the large-mouthed black bass, *Micropterus salmoides*, taken at the same time and place, had eaten nothing but the young gizzard shad (Dorosoma).

Comparing the food of four examples of the channel cat *(Ictalurus punctatus)* with seven croppies (Pomoxys), both taken at Peoria, Apr. 10, 1878, I found that aquatic insects made ninety-eight per cent. of the food of the latter, seventy per cent. being Hexagenia larvæ, while only sixty-two per cent. of the food of the catfishes consisted of insects (ephemerid larvæ twenty-eight per cent.), the remainder consisting of vegetation and scraps of dead fishes.

A contrast equally decided is shown by three specimens of the gizzard shad (Dorosoma) and four of the rock bass *(Ambloplites rupestris)*, all obtained at Ottawa, July 8, 1879. The former had swallowed large quantities of fine mud containing about twenty per cent. of minutely divided vegetable *débris*, while the latter had fed wholly upon insects, fishes, and crayfishes,—the first chiefly aquatic larvæ.

Even in the shallow muddy pools left behind in the retreating overflow of the Mississippi in southern Illinois, fishes of the same size but differing widely in alimentary structures exhibit corresponding differences in the selections made from the

meager food resources of their localities. Two of the common blunt-jawed minnows *(Hybognathus nuchalis)* had fed here almost wholly upon mud mixed with Algæ and miscellaneous vegetation; while three of the little pirate perch (Aphredoderus) had eaten little but Chironomus larvæ, half the food of one of the specimens being wholly small fishes, and insignificant quantities of Entomostraca occurring in the stomachs of the others.

A small collection, made from the Little Fox River, in White county, in southern Illinois, Oct. 5, 1882, of four specimens each of Labidesthes and *Zygonectes notatus* enables us to bring into comparison the food of two extremely different species taken together from the same pools in a running stream. The Labidesthes, although predaceous in habit and feeding most commonly upon Entomostraca, was here giving its attention wholly to terrestrial insects,— more than two thirds of them winged Chironomus; while the Zygonectes had eaten in addition to thirty-seven per cent. of terrestrial insects (scarcely any of them Chironomus imagos), about thirty per cent. of aquatic vegetation, nine per cent. of Entomostraca, eleven per cent. of aquatic insects, and fourteen per cent. of mollusks. These differences in food have no apparent relation to the essential structural differences of the species, but must be considered an illustration of the various effect of like conditions when applied to different species.

On the other hand, three bull-heads *(Amiurus nebulosus)* and six common perch (Perca) taken from Fox River, at McHenry, May 9, 1880, did not differ remarkably in food, both groups having eaten crayfishes, mollusks, aquatic insects, and vegetation. One of the catfishes had taken another fish, and one had eaten leeches. It is to be noted, however, that these species are both bottom feeders, and that both lots of these specimens had taken about the average food of their kind.*

The above are examples of the food relations of fishes widely separated from each other in the classification and decidedly different in alimentary structures and in feeding habits. Illustrations of the differences in food apparent in

* See Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 3, p. 35.

species allied in classification but differing with respect to the structures concerned in the appropriation of food are given by the following examples.

Two species of minnows, *Chrosomus erythrogaster* and *Semotilus atromaculatus* — the first represented by fourteen specimens, and the second by six, all collected from a small tributary of the Fox, near Plano, Sept. 8, 1882 — were brought into comparison with reference to their food, with the result that the characteristic differences of the species, as shown in the general discussion of the group published in our Bulletin 6, Vol. I., were clearly manifested by this small number. In the former lot seventy-five per cent. of the food was mud, the remainder being indiscriminate vegetable *débris*; while in the latter the entire mass consisted of insects (chiefly terrestrial) except a single insect parasite (Gordius).

From one of the permanent ponds or so-called lakes of southern Illinois, covered in September with a film of Wolffia and other vegetation, three specimens of *Gambusia patruelis* and five of *Umbra limi* were examined. The former had eaten little but Wolffia, which amounted to more than ninety per cent. of the food, the remainder consisting of Entomostraca, mollusks, and aquatic insect larvæ, while the Wolffia made less than sixty per cent. of the food of the Umbra,— about one fourth consisting of Entomostraca, and the remainder of unrecognized insects.

Two minnows of similar range (*Phenacobius mirabilis* and *Notropis whipplei*) agree essentially in gill structure and pharyngeal teeth, and differ but little in the relative length of intestine; and they have consequently been placed by me in the same alimentary group.* They are unlike, however, in the form of the mouth and in their haunts and feeding habits. This difference is reflected in the food of a small collection made in the Galena River, in April, 1880, three specimens of Phenacobius having eaten only aquatic larvæ and pupæ (nearly all chironomid), while the food of the Notropis, represented by six specimens, was of a varied character, containing few aquatic larvæ (only one per cent. of Chironomus), but consisting chiefly of miscellaneous collections of terrestrial insects,

* Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 6, p. 76.

seeds and anthers of terrestrial plants, and other accidental rubbish.

From a collection made at Henry, Illinois, Nov. 1, 1887, four specimens of croppie (*Pomoxys nigromaculatus*) are comparable with five sunfishes (*Lepomis pallidus*), and three large-mouthed black bass (*Micropterus salmoides*) may be compared with three striped bass (*Roccus chrysops*). Eighty-four per cent. of the food of the Pomoxys consisted of Hexagenia larvæ, an additional six per cent. being other aquatic larvæ, and the remaining ten per cent. consisting of fishes; while the Lepomis had eaten but twelve per cent. of Hexagenia larvæ, eight per cent. of other aquatic insects, and no fishes at all, — the remaining elements being terrestrial insects (about one fourth), worms (Nais and Lumbriculus, fifteen per cent.), and mollusks (thirty-seven per cent.).

The black bass had eaten chiefly fishes and a mouse, together with a few aquatic insects; while the food of the striped bass was nearly all ephemerid larvæ with only a trace of fishes.

A collection of small fishes, made from Mackinaw Creek, in Woodford county, August 20, 1879, affords an interesting opportunity to compare the food of a number of the smaller species (cyprinoids, darters, etc.). About half that of four specimens of *Notropis megalops* collected there, consisted of insects, the remainder being terrestrial and aquatic vegetation; and substantially the same statement may be made with respect to six specimens of *Notropis whipplei*, — these two species belonging respectively to the third and fourth groups of my paper on the "Food of the Smaller Fresh Water Fishes."*

Two specimens of *Hybopsis biguttatus*, on the other hand, had eaten only aquatic vegetation; and two examples of Phenacobius — a species extremely darter-like in its haunts and habits — had taken only Chironomus larvæ.

The darters were represented by four examples of Boleosoma and six of Hadropterus, the former and smaller species having eaten mostly Chironomus larvæ and Entomostraca, — eighty-nine per cent. and eleven per cent. respectively, — while the larger had taken only aquatic larvæ, — nearly all ephemerids.

* Bull. Ill. St. Lab. Nat. Hist., Vol. I., No. 6, p. 76.

Finally, eight of the slender, active, and wholly predaceous little brook silversides (*Labidesthes sicculus*) had eaten a single fish, fourteen per cent. of Entomostraca, and about eighty per cent. of insects — somewhat more than half of aquatic origin. In brief, the structures of Labidesthes, the habits of Phenacobius and the darters, and the differences in size of the species of Boleosoma and Hadropterus were all reflected in the food of this little group.

The obverse fact of the unifying effect of similarity of alimentary structures is apparently shown by a small collection of minnows, all belonging to the first two groups of the paper cited above*, made from an extremely muddy little creek in Jersey county, which contained no visible vegetation and few, if any, Entomostraca. Twelve of these fishes, representing the genera Campostoma, Pimephales, Hyborhynchus, Hybognathus, and Notemigonus, agreed in food almost precisely, all having swallowed the fine mud of the creek bottom, with a slightly varying admixture of unicellular Algæ and vegetable *débris*.

As an example of a contrast between two species agreeing in alimentary structures, but differing in size and somewhat, also, in habitual range, we may take three examples of *Notropis heterodon* and three of *Notropis megalops*, captured at McHenry, May 8, 1880. More than half the food of the latter group consisted of vegetation, and of the former only ten per cent. The remaining ninety per cent. of the food of *heterodon* was Entomostraca ; but these were not represented at all in the *megalops*, the remaining food of these specimens consisting of insects and amphipod Crustacea.

Sensible and even conspicuous differences in food often appear between groups which are neither widely separate in classification nor yet distinguished by marked differences in alimentary structures, as between species of the same genus. Sometimes these are apparently due to differences in habit with respect to the search for food; but sometimes seem dependent upon distinction of habit or preferences even more obscure.

Six specimens of the channel cat (*Ictalurus punctatus*), taken at Peoria, October 6, 1887, had eaten insects, mollusks, and vegetation at the rate of forty-one, nineteen, and forty per cent. respectively, the vegetation being nearly all Cladoph-

* See the preceding page.

ora and Potamogeton; while the same number of bull-heads (*Amiurus nebulosus*) had derived thirty-seven per cent. of their food from insects, and sixty-three per cent. from mollusks. The difference here was substantially a larger ratio of mollusks for Amiurus, replacing the vegetable food of the Ictalurus group. By a comparison of these differences with those detected between the species at large, as explained on pages 456–461, it will be seen that the former do not represent the specific differences in food, but simply give evidence that two species may be differently affected by the same conditions.

Other specific differences in the same genus are shown by the collections made Oct. 27, 1875, from Peoria Lake. Eight examples of the wall-eyed pike (*Stizostedion vitreum*) had eaten only soft-finned fishes, — excepting one small sunfish, — while four of ten specimens of the related species *S. canadense*, had eaten spiny-finned fishes, and in only three were the fishes recognizable as belonging to the soft-finned species. Three specimens of Micropterus taken with the above had eaten crayfishes and fishes (including a catfish).

Among my specimens of the sucker family (Catostomatidæ), a lot obtained at Quincy, Aug. 25, 1887, are comparable for the present purpose. Four examples each of *Ictiobus urus* and *I. cyprinella* presented a decided contrast with respect to the elements of their food, that of *I. urus* consisting almost wholly of Chironomus larvæ, with large quantities of dirt, while three of the specimens of *I. cyprinella* had eaten scarcely anything but Algæ, ninety per cent. of the food of the fourth being Chironomus larvæ, and the remainder, larvæ of Neuroptera,— Hexagenia and Corydalis.

On the other hand, two small collections of the same species made at Peoria, Oct. 9, 1878 — four of *I. urus* and five of *I. cyprinella* — exhibit similar food, composed chiefly of Entomostraca, Chironomus larvæ, distillery waste (meal, etc.), and aquatic vegetation. The *urus* group alone had eaten Entomostraca, these being replaced in the other by a larger quantity of meal.

The facts above recited are evidence that fishes are not mere animated eating-machines, taking indiscriminately and indifferently whatever their structures fit them to capture, to

strain from the waters, or to separate from the mud, but that psychological preferences as well as physical capabilities have something to do with their choice of food.

THE STRUCTURES OF ALIMENTATION.

A brief review of the principal facts respecting the structures of alimentation in fishes will be necessary to exhibit clearly the relation of habit and organization in this particular.

These structures may be conveniently divided into those of *search*, of *prehension*, of *mastication*, and of *digestion*. Means of defence and escape may also properly be mentioned, as belonging to the obverse side of the food relation.

Structural peculiarities relating to the methods and situation of the search for food are illustrated by the barbels of the catfishes and the sturgeons, the shovel of Polyodon, the square head of the stone roller, the flat heads of the top minnows, and the pointed snouts of the darters,— which fit them for prying about between and under stones in running water. Similarly related, are the bare breasts of many darters and the large pectoral fins of the stone roller and Phenacobius.

The structures of food prehension are the lips, the jaws, the teeth, and the gill-rakers, with which should be considered, perhaps, the gill slit or branchial opening. The sucking lips of the Catostomatidæ, organs of touch as well as of prehension, are of course related to the mud-searching habit of these fishes, the protractile jaws aiding in this use. The stout wide jaws of the catfishes, with their wide bands of minute, pointed teeth, are probably to be understood as an apparatus for seizing, holding, and pulling about relatively large objects, whether hard or soft, and are perhaps most useful in feeding upon mollusks. The very large but weak jaw of the shovel fish is explained by the minute character of its food, which offers no resistance, but necessitates the passage of large quantities of water through the mouth; while the long and slender jaws of the long-nosed gar (Lepidosteus) armed with several rows of acute raptatorial teeth, are the best apparatus in our waters for the destruction of a relatively small but active living prey.

The teeth of our fresh-water fishes are always pointed and acute, there being no examples of pavement teeth or cutting incisors among them, such as are found in several marine forms, nor are there any instances of either jaw being toothed and the other not. The evanescent teeth of the young of several species which become toothless when mature, are sometimes to be understood as rudiments, as in the shovel fish, and sometimes as related to the early food, as in the white-fish and the gizzard shad.

The gill-rakers of fishes vary widely in number, length, and usefulness, but are as important and significant as any other part of the feeding apparatus. As they oppose the only obstacle to the escape through the gill slit, of objects which enter the mouth with the water of respiration, they set the minimum of size for objects of the fishes' food, the only exception to this rule being afforded by the few fishes which swallow mud with little or no discrimination.

They are usually arranged in two rows on each gill arch, with frequently one also on the pharyngeal, behind the last gill slit. Occasionally only one row is developed on each gill (lake "herring"), and commonly the second row, if present, is less prominent than the first. The shovel fishes are, however, an exception to this latter statement, for in them both rows are equally and remarkably developed. As the anterior rakers guard the relatively large passage-way between the foremost gill and the opercle, while the other rows merely prevent the escape of objects between the several pairs of gills, the anterior row is almost invariably longer than the remaining series. The shovel fish and the gizzard shad are exceptions. The rakers of this row are commonly longest in the middle of the arch, shortening toward each end; but the particulars of this disposition depend on the length and shape of the arch and the concavity of the inner surface of the opercle. In the gizzard shad, however, the short but very numerous and fine gill-rakers project in a nearly horizontal direction.

The gill-rakers, when short and ineffective, are often armed with minute denticles, variously arranged, but are never branched or pinnate. In several of the sucker family, the rakers of the lower horizontal arm of the arch are represented

by a thick, broad pad, transversely ridged (the ridges representing the separate rakers) so that when approximated these structures form a continuous floor for the sides of the buccal cavity. The rakers may vary in number in different species from ten or twelve in a series, as in some sunfishes, to more than five hundred, as in the shovel fish; and in length from mere tubercles, to two or three times the length of the corresponding filaments of the gill. Rarely they are completely wanting, as in the pike. The anterior row is commonly so set upon the arch as to be obliquely divaricated by the separation of the branchial structures, being thus automatically adapted to the respiratory movements.

They are little developed in young fishes, the small branchial arches and the narrow slits between them serving to separate from the water the minute objects of the earliest food. Their development with the growth of the fish simply enables it to retain as elements of its dietary, objects which the coarseness of its branchial structures would otherwise compel it to forego.

Concerning their relations to food prehension, we may say in general that if numerous, long, and fine, they indicate the importance of Entomostraca to the fish. If less numerous, but moderately long and stout, in a fish of medium size, we may presume that insects form a considerable ratio of the food. If wanting, or rather short and strong, the presumption is (except for the smaller fishes) that the species is either piscivorous or feeds largely upon mollusks, the dental and pharyngeal apparatus easily showing which.

The pike-perch (Stizostedion) is somewhat remarkable in the fact that although strictly piscivorous when adult, it has long and strong gill-rakers, much longer in fact than in the less piscivorous related species, the common perch. In this case the rakers seem to have been retained, and even further developed, as a basis of attachment for several rather large recurved teeth borne on their inner surfaces, useful in preventing the escape of a living prey.

The masticatory apparatus of fishes (sometimes wanting) comprises always a pair of pharyngeal bones,—the lower pharyngeal jaws, a pair of modified branchial arches. These are

commonly opposed by superior pharyngeals, which most frequently consist of osseous and cuticular thickenings of the upper ends of the gill arches, — sometimes of only one or two, as in the catfish family, sometimes of all, as in the sunfishes. In the cyprinoids, the upper pharyngeal is a quadrate or triangular pad, rarely, if ever, toothed, borne upon an oblique, expanded process of the basioccipital. In the sucker family the sickle-shaped lower pharyngeals act against a more or less indurated palatal arch supported by the same cranial process, the firmness and width of this hardened band varying with the development of the lower arches of the apparatus. In most of the Acanthopteri and in the catfish family the lower pharyngeals have a fusiform outline, varying in width according to the food, the upper surface set with minute denticles, sharp-pointed in the insectivorous species, more or less blunt and conical in those which take a considerable percentage of molluscan food. The immense development of these structures in the sheepshead (Aplodinotus), as a crushing apparatus for Mollusca, is too well known to require description. In the Catostomatidæ the number of teeth may vary from thirty or less to two hundred or more, reduction in number going with increase in size (especially in the lower part of the arch,) both being related to an increased importance of molluscan food.

In the cyprinoids or minnow family, this is practically an insectivorous apparatus, except in some of the species with very long intestine and the limophagous habit, where it seems useful chiefly as a means of grinding up the mud ingested.

In the piscivorous species, and in those with highly developed gill-rakers, the lower pharyngeals are commonly slight and insignificant; but in the former group the upper pharyngeals may be preserved and enlarged as a basis for the insertion of hooked teeth, to aid in the retention of their struggling prey.

Concerning the digestive structures, I will only remark that the fishes with the longest intestine are mud-feeders, as a rule, and that in one of them, — the gizzard shad, a mud lover, *par excellence*, — the pharyngeal jaws (which in the mud-eating cyprinoids are evidently used to grind the food) are function-

ally replaced by a bulbous, muscular stomach, the pharyngeals themselves being reduced to thin and delicate plates, scarcely better than rudiments.

In this connection the adult size of the fish ought always to be mentioned, since this has, perhaps, at least as much to do with the food as any structural endowment, and frequently, in fact, has had a determining influence on the latter. Many fishes can enjoy the advantages of large size only on condition that they acquire some new capacity of food prehension, adapting them to new food relations. Simple and symmetrical growth of a small fish would render it incapable of straining out Entomostraca without fitting it for the appropriation of any other food, except, perhaps, the larger Crustacea and some aquatic insects; and beyond this insectivorous stage nothing is possible without new adaptations.

CORRELATIONS OF ALIMENTARY ORGANS.

Correlations of structure may be either mediate or immediate, in the latter case modification of one organ being directly dependent on modification of another, and in the former both parties to the correlation being modified by a common cause. The immediate class of correlations are relatively few and simple in the alimentary structures of fishes, while several of the mediate class are less obvious and more suggestive. That a fish with canine teeth has a strong jaw is a less interesting fact than the weakness of the jaw in one with long and numerous gill-rakers, or the incompatibility of canine teeth and heavy lower pharyngeals. The first is an immediate adaptive adjustment which a child might foresee, while the others are to be understood only when the peculiarities of the food are known to which both owe their character. The weak jaw of the shovel fish and the slight lower pharyngeals of the pike-perch illustrate the law of disuse (especially when we take into account the teeth of the young in the former and the large pharyngeals of the common perch), and the branchial apparatus of the shovel fish and the canine teeth of the pike-perch are examples of special adaptation to particular kinds of food.

Some mediate correlations are inverse, others coincident, the related structures varying oppositely or in the same direction. An interesting inverse correlation is exhibited by the gill-rakers and the pharyngeals in the suckers; as the former lengthen and multiply, the latter become weaker and bear smaller and more numerous teeth. The cause of this correlation is seen in the food, the species with heavy pharyngeals, few and large pharyngeal teeth, and few and short gill-rakers being mollusk feeders, and the other group depending largely on insects and crustaceans and using mollusks sparely, and then only the small and thin-shelled sorts. A similar inverse relation is seen between the large mouths and the weak pharyngeals of many piscivorous fishes; between the weak pharyngeals and the muscular stomach of the gizzard shad; and between the long gill-rakers and the rudimentary pharyngeals of the shovel fish. Such correlations are often evidence of a specialization and corresponding limitation of the feeding habit, — the increased efficiency of one structure corresponding to the increased importance to the fish of the related kind of food, and the defective development of the correlated structure indicating an abandonment of the food for whose appropriation it was especially fitted. On the other hand, the absence of these inverse correlations marks an omnivorous habit, — as in the catfishes, whose jaws, teeth, gill-rakers, and pharyngeals are all moderately developed, while the food is correspondingly indiscriminate.

DETAILED RECAPITULATION OF DATA.*

ANIMAL FOOD.

Dead animal matter: 1 Micropterus salmoides, Nov.; 6 Ictalurus punctatus, Mar., Apr., June, Aug.; 2 Amiurus natalis, May; 1 A. marmoratus, Oct.

Tadpoles: 2 Esox vermiculatus, June, July.

FISHES.

Ctenoid fishes: 1 Uranidea richardsoni, Aug.; 1 Esox lucius, Sept.

Cycloid fishes: 1 Stizostedion canadense, Nov.; 1 Esox lucius, May, Nov.; 2 E. vermiculatus, July; 1 Ictalurus punctatus, Aug.

ACANTHOPTERI.

Undetermined: 11 Stizostedion canadense, June; 1 Micropterus salmoides, Nov.; 3 Pomoxys, Oct., Nov.; 1 Esox lucius, Sept.; 1 Amia calva, Oct.

Aplodinotus grunniens: 2 Stizostedion canadense, Oct.

Percidæ: 1 Perca lutea, May.

Perca lutea: 8 Lota maculosa, Nov.; 1 Micropterus salmoides, May; 1 Amiurus nebulosus, May.

Etheostomatinæ: 1 Lepomis pallidus, Nov.

Etheostoma: 1 Perca lutea, Oct.

Percina caprodes: 1 Micropterus dolomiei, June.

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* The figures in the following lists show the number of examples of the species of fish in which the given food element was detected.

Where a family or other general name above that of a species occurs in the body of the list, the data placed against it are to be understood as relating only to specimens of the group not further determined; the species names, for example, placed against the family names Percidæ, Cyprinidæ, and the like, indicate the species and specimens in whose food *undetermined* examples of those families were noted—the more precise determinations being given lower down.

Boleosoma maculatum: 1 Pomoxys, Mar.

Centrarchinæ: 1 Stizostedion canadense, Nov.; 1 S. vitreum, Oct.; 4 Esox lucius, Sept., Oct.; 1 E. vermiculatus, 5 in., Oct.; 1 Amiurus nebulosus, Aug.

Micropterus: 1 Esox lucius, Nov.; 1 Lepidosteus platystomus, June.

M. dolomiei: 1 Stizostedion canadense, Nov.; 1 Esox lucius, Nov.

Lepomis: 1 Leptops olivaris, Aug.

Ambloplites rupestris: 1 Esox lucius, Nov.

Pomoxys: 1 Esox lucius, Sept.

HAPLOMI.

Gambusia patruelis: 1 Esox vermiculatus, July.

ISOSPONDYLI.

Coregonus artedi: 1 Lota maculosa, Nov.

C. clupeiformis: 1 Lota maculosa, Nov.

Dorosoma cepedianum: 2 Roccus interruptus, yg.; 4 Stizostedion canadense, Oct., Nov.; 7 S. vitreum, Apr., Oct.; 8 Micropterus salmoides, Nov.; 16 Esox lucius, Sept., Oct.; 2 Clupea chrysochloris, Sept., Oct.; 1 Amiurus natalis, Oct.; 1 Lepidosteus platystomus, Sept.; 2 L. osseus, July.

Hyodon: 1 Esox lucius.

EVENTOGNATHI.

Cyprinidæ: 2 Stizostedion vitreum, Oct.; 4 Perca lutea, May, Oct.; 1 Micropterus dolomiei, yg.; 1 Lepomis cyanellus; 1 Pomoxys, Oct.; 1 Aphredoderus sayanus, July; 3 Esox lucius, Nov.; 2 E. vermiculatus, July, Oct.; 1 Semotilus atromaculatus, July; 1 Amiurus natalis, Aug; 1 Leptops olivaris, Aug.; 2 Amia calva, May; 1 Lepidosteus platystomus, June; 1, $1\frac{3}{4}$ in., June; 1 L. osseus, July; 1, 2 in., July.

Semotilus atromaculatus: 1 Stizostedion vitreum, Oct.

Notropis: 1 Pomoxys, Mar.

N. hudsonius: 1 Esox lucius, Nov.

Campostoma anomalum: 1 Micropterus salmoides, Nov.

Catostomatidæ: 1 Aplodinotus grunniens, Sept.; 1 Esox lucius, Sept.; 1 Amiurus natalis, Aug.

Ictiobus: 1 Lepomis cyanellus, July; 2 Esox lucius, Nov.; 1 Amia calva.
I. bubalus: 1 Esox lucius, Sept.
Carpiodes: 1 Esox lucius, Nov.

NEMATOGNATHI.

Siluridæ: 1 Stizostedion canadense, Nov.; 1 Micropterus salmoides, Oct.
Amiurus: 1 Stizostedion canadense, Oct.; 1 Leptops olivaris, Aug.
Noturus flavus: 1 Micropterus dolomiei; June.

MOLLUSCA.

GASTEROPODA.

Pleurocera: 1 Ictalurus punctatus, Sept.
Amnicola: 4 Lepomis gibbosus, May, July, Aug.; 1 L. notatus, Sept.; 1 L. pallidus, Oct.; 2 Placopharynx carinatus, Oct.; 1 Moxostoma, Nov.; 1 M. macrolepidotum, Sept.; 1 Minytrema melanops, Oct.; 1 Ictalurus punctatus, Oct.; 3 Amiurus nebulosus, May, Aug., Oct.
Somatogyrus: 3 Moxostoma macrolepidotum, Sept.
Valvata tricarinata: 1 Perca lutea, May; 2 Lepomis gibbosus, May; 2 Notemigonus chrysoleucus, May; 1 Placopharynx carinatus, Oct.; 2 Moxostoma macrolepidotum, Sept; 1 Ictiobus urus, Aug.; 1 Amiurus nebulosus, July.
V. sincera: 1 Gambusia patruelis, Sept.
Vivipara: 2 Lepomis pallidus, July, Nov.; 1 Moxostoma aureolum, June; 3 M. macrolepidotum, Sept., Oct.; 1 Ictiobus bubalus, Oct.; 7 Ictalurus punctatus, Apr., Sept., Oct.; 2 Amiurus natalis, Oct.; 1 A. marmoratus, Oct.; 1 Amia calva, Aug.
Melantho: 1 Moxostoma, Nov.; 3 M. macrolepidotum, Oct.; 7 Ictalurus punctatus, Sept., Oct.; 1 Amiurus natalis, Oct.; 1 A. nebulosus, Oct.
M. decisa: 2 Aplodinotus grunniens, Oct.
Lioplax subcarinata: 2 Ictalurus punctatus, Sept.
Succinea: Perca lutea, Aug.

Limnæa: 1 Notropis whipplei, Apr.; 1 Moxostoma macrolepidotum, May.

Physa: 1 Lepomis gibbosus, yg.; 2 L. pallidus, Nov.; 1 Umbra limi, Sept.; 3 Gambusia patruelis, Sept., Oct.; 1 Zygonectes dispar, July; 3 Z. notatus, Sept., Oct.; 1 Moxostoma macrolepidotum, May; 2 Amiurus natalis, 2⅛ in., July; 3 A. nebulosus, Aug., Sept.; 1 A. marmoratus, Aug.

P. heterostropha: 2 Perca lutea, May; 1 Amiurus nebulosus, Oct.

Planorbis: 1 Aplodinotus grunniens, June; 1 Lepomis gibbosus, July; 1 L. notatus, Sept.; 1 L. pallidus, Nov.; 1 Umbra limi, July; 1 Gambusia patruelis, Sept.; 1 Zygonectes dispar, July; 2 Fundulus diaphanus, June, Oct.; 2 Moxostoma macrolepidotum, May, Sept.; 2 Ictiobus bubalus, Oct.; 1 Ictalurus punctatus, Oct.; 1 Amia calva, Aug.

P. deflectus, yg.: 1 Notemigonus chrysoleucus, May.

Ancylus: 1 Percina caprodes, Aug.

LAMELLIBRANCHIATA.

Sphærium: 2 Aplodinotus grunniens, June, Oct.; 1 Perca lutea, Oct.; 1 Lepomis pallidus, Oct.; 1 Dorosoma cepedianum; 1 Placopharynx carinatus, Oct.; 4 Moxostoma, June; 1 M. aureolum, June; 3 M. macrolepidotum, June, Sept.; Minytrema melanops, Sept., Oct.; 2 Hypentelium nigricans, Aug.; 1 Catostomus teres, Oct.; 3 Ictiobus velifer, Aug., Oct.; 7 I. bubalus, Aug., Oct.; 4 I. urus, Aug., Nov.; 2 I. cyprinella, June, Oct.; 13 Amiurus nebulosus, May, Sept., Oct.; 1 A. marmoratus, Oct.; 2 Amia calva, Sept.

S. sulcatum: 1 Ictiobus bubalus, Oct.; 4 Amiurus nebulosus, Sept.; 1 A. marmoratus, Aug.

Pisidium: 1 Fundulus diaphanus, June; 1 Amiurus nebulosus, Sept.

Unionidæ: 1 Lepomis notatus, Sept.; 1 Labidesthes sicculus, Oct.; 1 Ictiobus urus, Apr.; 2 Ictalurus punctatus, Sept.; 2 Amiurus nebulosus, May, Oct.; 1 A. marmoratus, Oct.

Unio: 1 Aplodinotus grunniens, June; 1 Perca lutea, May; 2 Lepomis gibbosus, yg.; 1 Moxostoma macrolepidotum, May; 1 Catostomus teres, June.

Anodonta: 2 Aplodinotus grunniens, June; 1 Lepomis megalotis, June; 2 Ictalurus punctatus, Aug., Oct.

INSECTA.

Eggs: 4 Lepomis gibbosus, yg.; 1 L. pallidus, July; 1 Hyodon tergisus, Oct.; 1 Notropis hudsonius, June; 1 N. stramineus, Apr.; 1 Amiurus natalis, Nov.

Pupæ: 1 Perca lutea, Oct.; 1 Hadropterus phoxocephalus, Apr.; 1 Notropis megalops, June; 1 N. whipplei, Aug.

Larvæ: 1 Uranidea richardsoni, Aug.; 1 Micropterus salmoides, yg.; 1 Lepomis pallidus, yg.; 2 L. megalotis, June; 1 L. cyanellus, yg.; 1 Ambloplites rupestris, July; 1 yg.; 1 Umbra limi, Sept.; 1 Zygonectes notatus, Sept.; 1 Dorosoma cepedianum, 2½ in., July; 1 Semotilus atromaculatus, July; 1 Notropis megalops, June; 1 N. whipplei, June; 1 Moxostoma aureolum, June; 1 M. macrolepidotum, May; 1 Ictiobus urus, Aug.; 2 I. cyprinella, July; 2 Ictalurus punctatus, Apr., June; 2 Amiurus natalis, 2–2⅛ in., July.

Terrestrial: 1 Dorosoma cepedianum, July; 3 Hyodon tergisus, May, June, Aug.; 3 Notropis megalops, May, July, Aug.; 1 N. whipplei, June; 1 Ictiobus bubalus, Oct.; 1 I. cyprinella, Oct.

Terrestrial pupæ: 1 Notropis analostanus, Oct.

Aquatic: 1 Notropis whipplei, June; 2 Ictiobus bubalus, Oct.; 1 Ictalurus punctatus, Sept.; 1 Polyodon spathula, Aug.

Aquatic larvæ: 3 Uranidea richardsoni, Aug.; 1 Lepomis gibbosus, yg.; 1 L. notatus, Sept.; 1 L. pallidus, July; 3 Aphredoderus sayanus, Sept.; 1 Semotilus atromaculatus, May; 1 Hybopsis biguttatus, Aug.; 3 Notropis megalops, May, June; 3 N. whipplei, Apr., June; 1 N. lutrensis, July; 1 N. heterodon; 1 Hypentelium nigricans, Aug.; 1 Ictiobus velifer, Oct.; 1 I. urus, Aug.; 1 I. cyprinella, Oct.; 1 Ictalurus punctatus, Apr.; 1, 2½ in., Sept.; 2 Noturus gyrinus, June; 1 Polyodon spathula, June.

HYMENOPTERA.

Undetermined: 2 Lepomis pallidus, Nov.; 1 Pomoxys, May; 1 Labidesthes sicculus, Oct.; 4 Zygonectes notatus, July, Sept., Oct.; 1 Semotilus atromaculatus, June; 1 Notropis atherinoides, Apr.; 1 N. megalops, June; 1 N. whipplei, Apr.

Apis mellifica: 1 Hyodon tergisus, May; 1 Ictalurus punctatus, Oct.

Sphegidæ: 1 Hyodon tergisus, Oct.

Larrada montana: 1 Hyodon tergisus, Oct.

Formicidæ: 1 Lepomis pallidus, Nov.; 1 Centrarchus macropterus, July; 1 Coregonus artedi, 6 in., Aug.; 3 Semotilus atromaculatus, July, Aug.; 1 Notropis megalops, July; 3 N. whipplei, Aug.; 1 Ictalurus punctatus, Oct.; 1, $3\frac{1}{2}$ in., Sept.

Myrmicidæ: 1 Gambusia patruelis, Sept.; 1 Zygonectes notatus, Sept.; 1 Coregonus artedi, Oct.; 1 Ictalurus punctatus, Oct.

Solenopsis: 1 Zygonectes notatus, July.

Chalcididæ: 2 Labidesthes sicculus, Oct.; 1 Fundulus diaphanus, Oct.

Eurytominæ: 1 Clupea chrysochloris, $2\frac{1}{4}$ in., Sept.

Ichneumonidæ: 1 Lepomis pallidus, July.

Amblyteles subrufus: 1 Hyodon tergisus, Oct.

LEPIDOPTERA.

Undetermined: 1 Coregonus artedi, Oct.; 2 Hyodon tergisus, Oct.; 1 Hybopsis biguttatus, Nov.; 3 Notropis megalops, July, Aug.; 1 N. whipplei, June.

Larvæ: 3 Lepomis pallidus, May, July, Nov.; 1 Ambloplites rupestris, yg.; 1 Semotilus atromaculatus, July; 1 Hybopsis biguttatus, June; 1 Notropis atherinoides, Apr.; 2 N. whipplei, Aug.; 1 Pimephales promelas, May; 1 Ictalurus punctatus, Oct.

Heteroccra: 1 Notemigonus chrysoleucus, July.

DIPTERA.

Terrestrial: 2 Lepomis cyanellus, yg.; 6 Labidesthes sicculus, June, Aug., Oct.; 1 Coregonus artedi, 2 in., Aug.; 1 Clupea chrysochloris, $2\frac{1}{4}$ in., Sept.; 1 Hyodon tergisus, Oct.; 2 Notemigonus chrysoleucus, Sept.; 3 Semotilus atromaculatus, June, Sept.; 2 Notropis atherinoides, July; 2 N. whipplei, Aug.; 2 N. heterodon, May, July; 1 Moxostoma macrolepidotum, Sept.; 2 Ictalurus punctatus, Apr.; 1 Amiurus nebulosus, 2 in., Aug.; 1 Noturus flavus, Oct.; 1 Polyodon spathula, Aug.

Aquatic larvæ: 2 Uranidea richardsoni, Aug.; 2 Aplodinotus grunniens, June, Sept.; 1 Roccus chrysops, Nov.; 1 Etheostoma fusiforme, July; 3 E. cœruleum, June, July; 2 E. zonale, June; 1 Hadropterus phoxocephalus, Apr.; 1 Percina caprodes, Aug.; 1 Boleosoma maculatum, July; 1 Ammocrypta pellucida, June; 2 Lepomis gibbosus, yg.; 1 L. megalotis, June; 1 L. cyanellus, yg.; 2 Chænobryttus gulosus, yg., 1 Ambloplites rupestris, July; 3 Pomoxys, Apr.; 5 Aphredoderus sayanus, Sept.; 4 Eucalia inconstans, Oct.; 1 Umbra limi, July; 1 Gambusia patruelis, Sept.; 4 Zygonectes notatus, June, Sept., Oct.; 7 Fundulus diaphanus, June, Oct.; 1 Dorosoma cepedianum, $2\frac{1}{2}$ in., July; 1 yg.; 1 Hybopsis biguttatus, Sept.; 1 Notropis atherinoides, Aug.; 2 N. megalops, May; 4 N. whipplei, June; 1 N. stramineus, Apr.; 4 N. heterodon, May, July; 1 Pimephales promelas, May; 1 Placopharynx carinatus, Oct.; 1 Moxostoma, Nov.; 1 M. aureolum, June; 5 M. macrolepidotum, June, Sept., Nov.; 1, 2 in., July. 1 Minytrema melanops, Oct.; 1 Erimyzon sucetta, $3\frac{1}{4}$ in.; 2 Hypentelium nigricans, Aug.; 8 Ictiobus velifer, Apr., July, Oct.; 1 I. bubalus, Oct.; 7 I. urus, Apr., June, July, Aug., Oct., Nov.; 4 I. cyprinella, Apr., June, July, Oct.; 12 Ictalurus punctatus, Apr., May, June, Aug., Oct.; 1, $2\frac{1}{2}$ in., Sept.; 4 Amiurus, yg.; 1 A. natalis $2\frac{1}{2}$ in., July; 2 A. nebulosus, Oct.; 3 Noturus gyrinus, May, Oct.; 2 Polyodon spathula, May, June.

Nemocera: 2 Notropis atherinoides, Aug.; 4 N. whipplei, May; 1 N. heterodon, May.

Brachycera: 4 Labidesthes sicculus, Oct.; 1 Zygonectes notatus, Sept.; 5 Notropis whipplei, May, June.

Simulium, larvæ: 1 Eucalia inconstans, June; 1 Notropis atherinoides, Apr.; 2 N. whipplei, June.

Bibio albipennis: 1 Notropis atherinoides, May.

Culicidæ: 1 Alvarius punctulatus, May; 1 Lepomis cyanellus, yg.; 1 Aphredoderus sayanus, July; 1 Zygonectes notatus, June; 1 Clupea chrysochloris, $2\frac{1}{4}$ in., Sept.; 2 Notropis atherinoides, July; 1 Noturus gyrinus, Sept.

Culicidæ, larvæ: 2 Micropterus dolomiei, yg.; 1 M. salmoides, yg.; 1 Polyodon spathula, May.

Corethra, larvæ: 1 Pomoxys, Oct.; 4 yg.; 7 Aphredoderus sayanus, Aug., Sept.; 1 Dorosoma cepedianum, yg.; 2 Amiurus nebulosus, Aug.; 1 A. marmoratus, Oct.; 3 Polyodon spathula, May, Aug.

Chironomidæ: 3 Aplodinotus grunniens, yg.; 1 Roccus interruptus, yg.; 17 Labidesthes sicculus, June, Aug., Oct.; 2 Zygonectes notatus, Oct.; 1 Fundulus diaphanus, Oct.; 1 Phenacobius mirabilis, Oct.; 1 Notropis heterodon, May; 2 Ictiobus urus, Aug.

Chironomidæ, larvæ and pupæ: 3 Aplodinotus grunniens, yg.; 1 Roccus interruptus, yg.; 1 Roccus chrysops, Nov.; 2 yg.; 1 Perca lutea, May; 6 yg.; 8 Alvarius punctulatus, May, June; 3 Etheostoma fusiforme, July; 2 E. jessiæ, Sept.; 6 E. cœruleum, June, July, Aug.; 5 E. lineolatum, Apr., May, June, July; 2 E. zonale, June; 3 Hadropterus aspro, Aug.; 2 H. phoxocephalus, Apr., Aug.; 9 Percina caprodes, Apr., Aug., Sept.; 1 Boleosoma camurum; 9 B. maculatum, Apr., July, Aug.; 2 Crystallaria asprella, June; 3 Ammocrypta pellucida, June; 2 Micropterus dolomiei, yg.; 2 M. salmoides, yg.; 3 Lepomis gibbosus, May, July, Aug.; 13 yg.; 1 L. notatus, Sept.; 2 L. pallidus, July, Nov.; 11 yg.; 4 L. megalotis, June; 5 L. cyanellus, yg.; 4 Chænobryttus gulosus, yg.; 3 Ambloplites rupestris, yg.; 7 Pomoxys, Apr., May, Nov.; 13 yg.; 2 Centrarchus macropterus, July; 4 yg.; 8 Aphredoderus sayanus., Aug., Sept.; 1 Labidesthes sicculus, July; 5 Eucalia inconstans, June; 2 Fundulus diaphanus, Oct.; 2 Dorosoma cepedianum, $2\frac{1}{2}$–$5\frac{1}{4}$ in., July, Oct.; 1 yg.; 1 Hyodon tergisus, 2$\frac{3}{4}$ in., June; 1 Cyprinidæ, yg.; 1 Notemigonus chrysoleucus, July; 3 Hybopsis biguttatus, June, Sept.; 9 Phenacobius mirabilis, Apr., Aug., Sept., Oct.; 3 Notropis, yg.; 5 N. whipplei, Apr., June, July; 1 N. hudsonius, May; 4 N. heterodon, Apr., July; 1 Campostoma anomalum, Sept.; 2 Placopharynx carinatus, Oct.; 1 Moxostoma, June; 1 yg.; 3 M. aureolum, Apr.; 7 M. macrolepidotum, May, Aug., Sept., Nov.; 3, $1\frac{1}{4}$–$2\frac{3}{4}$ in., July, Aug.; 2 Minytrema melanops, Oct.; 2 Erimyzon succĕtta, $1\frac{3}{4}$–3 in., Oct.; 5 Hypentelium nigricans, Aug.; 10 yg.; 1 Catostomus teres, Oct.; 11 Ictiobus velifer, Mar., June, July,

Aug., Oct.; 14 I. bubalus, Apr., Aug., Sept., Oct.; 10 I. urus, July, Aug., Oct.; 6 I. cyprinella, June, July, Aug., Oct.; 12 Ictalurus punctatus, Apr., Aug., Sept.; 3, 2½–4 in., June, Sept.; 9 Amiurus, yg.; 5 A. natalis, 2–3½ in., July, Oct.; 3 A. nebulosus, Sept., Oct.; 2, 2½–3½ in., June, Aug.; 4 A. marmoratus, Oct.; 2 Noturus, yg.; 11 N. gyrinus, May, Aug., Sept., Oct.; 2 Amia calva, June, Sept.; 1 yg.; 5 Polyodon spathula, Aug., Sept., Nov.

Tipulidæ: 1 Coregonus artedi, Oct.; 1 Hyodon tergisus, Oct.; 1 Notropis atherinoides, Apr.

Tipulidæ, larvæ: 1 Notropis atherinoides, Apr.

Tipulidæ, eggs: 1 Coregonus artedi, Oct.; 1 Hyodon tergisus, Oct.

Tabanus, larvæ: 1 Ictalurus punctatus, Apr.; 1 Amiurus nebulosus, May.

Muscidæ: 1 Clupea chrysochloris, 2½ in., Sept.; 1 Hyodon tergisus, Oct.

Muscidæ, larvæ: 1 Micropterus dolomiei, yg.

COLEOPTERA.

Larvæ: 1 Roccus chrysops, Nov.; 1 Micropterus dolomiei, yg.; 1 Lepomis pallidus, July; 1 Ambloplites rupestris, yg.; 2 Pomoxys, Apr., May; 1 Notropis whipplei, June; 1 Ictiobus urus, July; 1 Noturus, yg.

Terrestrial: 3 Lepomis pallidus, July, Nov.; 1 Dorosoma cepedianum, July; 2 Hyodon tergisus, Oct.; 1 Semotilus atromaculatus, July; 1 Hybopsis biguttatus, Sept.; 1 Notropis atherinoides, May; 1 N. megalops, July; 1 N. whipplei, Aug.; 1 Moxostoma macrolepidotum, Aug.; 3 Hypentelium nigricans, Aug.; 1 Ictiobus bubalus, Oct.; 1 Amiurus marmoratus, Aug.; 1 Polyodon spathula, Nov.

Aquatic: 1 Hyodon tergisus, May.

Aquatic larvæ: 1 Aphredoderus sayanus, Oct.; 2 Hypentelium nigricans, Aug.; 1 Ictiobus cyprinella, July; 1 Noturus gyrinus, May.

Cicindelidæ: 1 Hyodon tergisus, Oct.

Carabidæ: 1 Lepomis pallidus, Nov.; 1 Notropis atherinoides, Apr.; 1 Ictalurus punctatus, Apr.; 1 Amiurus nebulosus, July.

Carabidæ, larvæ: 1 Ictiobus urus, July.
Clivina: 1 Hyodon tergisus, Aug.
Bembidium: 1 Notropis atherinoides, May.
Pterostichus sayi: 1 Hyodon tergisus, Oct.
Harpalini: 2 Lepomis pallidus, July, Nov.
Agonoderus pallipes: 1 Ambloplites rupestris, July; 1 Hyodon tergisus, Aug.; 1 Notropis atherinoides, Apr.; 1 Ictalurus punctatus, May.
Harpalus: 1 Semotilus atromaculatus, Sept.
Stenolophus: 1 Hyodon tergisus, Aug.
Anisodactylus discoideus: 1 Lepomis pallidus, Nov.; 1 Hyodon tergisus, Oct.
Haliplus: 1 Lepomis notatus, Sept.; 1 Semotilus atromaculatus, Aug.
Cnemidotus 12-punctatus: 1 Lepomis notatus, Sept.
Dytiscidæ: 1 Lepomis cyanellus, yg.; 1 Ambloplites rupestris, July.
Dytiscidæ, larvæ: 2 Micropterus dolomiei, yg.; 1 Lepomis pallidus, July; 1 Pomoxys, Apr.; 1 Ictalurus punctatus, Apr.; 1 Amiurus nebulosus, Oct.
Hydroporus undulatus: 1 Ambloplites, yg.
H. hybridus: 1 Lepomis notatus, Sept.
Coptotomus interrogatus: 1 Lepomis pallidus, July; 1 Polyodon spathula, May.
Cybister fimbriolatus: 1 Hyodon tergisus, Aug.
Gyrinidæ: 1 Amiurus nebulosus, Aug.
Gyrinidæ, larvæ: 1 Aplodinotus grunniens, Oct.; 3 yg.; 2 Lepomis pallidus, July, Nov.; 1 yg.; 1 L. megalotis, June; 4 Pomoxys, Apr., Nov.; 1 Notropis megalotis, Apr.; 1 Moxostoma macrolepidotum, Sept.
Hydrophilidæ: 2 Lepomis gibbosus, May, Aug.; 1 yg.; 1 Lepomis pallidus, May, July; 1 Fundulus diaphanus, Oct.; 1 Semotilus atromaculatus, Sept.
Hydrophilidæ, larvæ: 2 Aplodinotus grunniens, yg.; 1 Micropterus dolomiei, yg.; 1 Lepomis pallidus, July, Oct.; 2 Placopharynx carinatus, Oct.; 2 Moxostoma macrolepidotum; Sept.; 2 Ictiobus bubalus, Apr., Oct.; 1 Amiurus marmoratus, Aug.
Hydrophilus: 1 Lepomis cyanellus.

H. nimbatus: 1 Lepomis pallidus, July; 1 Ambloplites rupestris, July; 1 Hyodon tergisus, Oct.
H. glaber: 1 Hyodon tergisus, Oct.
Berosus striatus: 1 Hyodon tergisus, Oct.
Philhydrus: 3 Zygonectes notatus, Sept., Oct.
Silvanus: 1 Notropis atherinoides, Aug.
Histeridæ: 1 Hyodon tergisus, Oct.
Heterocerus: 1 Coregonus artedi, Oct.
H. undatus: 1 Ictiobus urus, July.
Staphylinidæ: 1 Lepomis cyanellus, yg.; 2 Zygonectes notatus, Oct.; 1 Fundulus diaphanus, Oct.; 1 Coregonus artedi, 6 in., Aug.; 1 Ictalurus punctatus, May.
Staphylinus tomentosus: 1 Ictalurus punctatus, Oct.
Elateridæ: 1 Lepomis pallidus, July; 1 Zygonectes notatus, July.
Drasterius elegans: 1 Hyodon tergisus, Aug.
Lampyridæ: 1 Hyodon tergisus, Oct.
Scarabæidæ: 1 Lepomis pallidus, Nov.; 1 Semotilus atromaculatus, July; 1 Notropis atherinoides, Apr.; 1 N. megalops, July.
Aphodius fimetarius: 1 Lepomis pallidus, May; 1 Hyodon tergisus, Oct.
A. inquinatus: 1 Lepomis pallidus, Nov.; 1 Notropis atherinoides, Oct.; 1 Polyodon spathula, Nov.
Melolonthinæ: 1 Notemigonus chrysoleucus, July.
Anomala binotata: 1 Chænobryttus gulosus.
Chalepus trachypygus: 2 Hyodon tergisus, Oct.
Tetramera: 1 Dorosoma cepedianum, July.
Chrysomelidæ: 1 Lepomis pallidus, Nov.; 1 L. megalotis, June; 1 Semotilus atromaculatus, July.
Cryptocephalus 4-maculatus: 1 Lepomis pallidus, Nov.
Colaspis brunnea: 1 Hyodon tergisus, Aug.
Doryphora 10-lineata: 1 Lepomis pallidus, Nov.
Diabrotica 12-punctata: 2 Lepomis pallidus, Nov.
D. vittata: 1 Coregonus artedi, Oct.
D. longicornis: 1 Hyodon tergisus, Aug.
Halticini: 1 Lepomis pallidus, Nov.
Disonycha limbicollis: 1 Hyodon tergisus, Oct.
Anthicidæ: 1 Coregonus artedi, 6 in., Aug.

Rhynchophora: 1 Notropis megalops, July; 2 N. hudsonius, May.
R. brevirostres: 1 Notropis hudsonius, May.
Curculionidæ: 1 Lepomis pallidus, Nov.
Macrops: 2 Hyodon tergisus, Aug., Oct.
Sphenophorus ochreus: 1 Hyodon tergisus, Oct.

HEMIPTERA.

Terrestrial: 1 Coregonus artedi, Oct.; 2 Notropis megalops, June, Aug.; 1 Ictiobus cyprinella, Oct.
Aquatic: 1 Zygonectes notatus, Oct.; 1 Notemigonus chrysoleucus, Sept.; 1 Notropis atherinoides, July; 1 N. hudsonius, May; 1 Hypentelium nigricans, yg.
Heteroptera: 1 Micropterus salmoides, yg.; 1 Zygonectes notatus, Sept.; 1 Fundulus diaphanus, Oct.; 1 Notropis atherinoides, May.
Terrestrial Heteroptera: 1 Fundulus diaphanus, Oct.; 1 Hyodon tergisus, Oct.
Amnestus: 1 Coregonus artedi, 6 in., Aug.
Pentatomidæ: 1 Lepomis pallidus, Nov.; 1 Hyodon tergisus, Oct.; 1 Ictalurus punctatus, May.
Podisus: 1 Ictalurus punctatus, Apr.
Euschistus: 1 Ictalurus punctatus, Oct.
Coreidæ: 1 Pomoxys, June.
Lygæidæ: 1 Gambusia patruelis, Sept.
Lygus pratensis: 1 Coregonus artedi, Oct.
Triphleps insidiosus: 1 Clupea chrysochloris, $2\frac{1}{4}$ in., Sept.
Tingitidæ: 1 Zygonectes notatus, Sept.
Piesma: 1 Notropis whipplei, Aug.
Tingis: 2 Zygonectes notatus, Sept.
Coriscus ferus: 1 Zygonectes notatus, Sept.; 1 Hyodon tergisus, Aug.
Melanolestes picipes: 1 Hyodon tergisus, Oct.
Hygrotrechus: 1 Ambloplites rupestris, yg.
Zaitha fluminea: 1 Micropterus salmoides, Nov.; 2 Hyodon tergisus, Oct.
Nepa: 1 Lepomis pallidus, May.
Ranatra: 1 Lepomis pallidus, July.
Notonecta: 1 Micropterus salmoides, yg.

Plea: 1 Gambusia patruelis, Sept.; 1 Ictalurus punctatus, May.

Corisa: 2 Perca lutea, yg.; 2 Hadropterus aspro, Aug.; 2 Percina caprodes, July, Sept.; 6 Micropterus dolomiei, yg.; 5 M. salmoides, yg.; 4 Lepomis pallidus, June, July, Nov.; 4 yg.; 1 Lepomis megalotis, June; 5 L. cyanellus, yg.; 1 Chænobryttus gulosus, Oct.; 1 yg.; 1 Ambloplites rupestris, yg.; 4 Pomoxys, Apr., May.; 4 yg.; 1 Centrarchus irideus, yg.; 3 Aphredoderus sayanus, July, Sept.; 1 Esox vermiculatus, 4 in., June; 1 Zygonectes dispar, July; 2 Z. notatus, Sept., Oct.; 1 Dorosoma cepedianum July; 3 Semotilus atromaculatus, July, Sept.; 1 Notropis megalops, Aug.; 1 N. whipplei, July; 2 Ictiobus urus, July, Aug.; 2 I. cyprinella, July; 1 Ictalurus punctatus, Apr.; 1 Amiurus nebulosus, Oct.; 1 Amia calva, June; 1 yg.; 1 Polyodon spathula, Aug.

C. alternata: 1 Perca lutea, yg.; 3 Micropterus salmoides, yg.; 1 Pomoxys, Apr.; 3 Zygonectes notatus, Sept.; 1 Ictalurus punctatus, Apr.; 1 Polyodon spathula, May.

C. signata: 4 Micropterus dolomiei, yg.

C. tumida: 2 Perca lutea, yg.; 1 Hadropterus aspro, Aug.; 8 Micropterus dolomiei, yg.; 3 M. salmoides, yg.; 1 Lepomis pallidus, Nov.; 1 L. megalotis; 1 L. cyanellus; 1 yg.; 1 Chænobryttus gulosus; 2 yg.; 3 Ambloplites rupestris, yg.; 1 Pomoxys, July; 1 yg.; 1 Centrarchus irideus, July; 1 Hyodon tergisus, 2⅞ in., June; 1 Amiurus nebulosus, 3½ in., June.

Homoptera: 1 Gambusia patruelis, Sept.; 1 Coregonus artedi, Oct.; 1, 6 in., Aug.; 1 Hyodon tergisus, Oct.; 2 Notropis whipplei, Apr., Aug.; 1 Ictalurus punctatus, May.

Tettigininæ: 1 Labidesthes sicculus, Oct.; 1 Zygonectes notatus, Oct.

Diedrocephala mollipes: 1 Coregonus artedi, Oct.

Typhlocyba: 1 Coregonus artedi, 2 in., Aug.; 1 Clupea chrysochloris, 2¼ in., Sept.

Aphididæ: 1 Gambusia patruelis, Sept.; 3 Zygonectes notatus, Sept., Oct.; 1 Notropis, yg.; 3 N. atherinoides, July, Aug.

Aphis: 1 Labidesthes sicculus, Oct.; 1 Zygonectes notatus, Oct.

Thrips: 1 Labidesthes sicculus, Oct.; 1 Zygonectes notatus, Oct.; 1 Fundulus diaphanus, Oct.; 1 Moxostoma, yg.

ORTHOPTERA.

Undetermined: 1 Hyodon tergisus, 2⅞ in., June; 1 Amiurus marmoratus, Aug.

Acrididæ: 1 Roccus interruptus, May; 3 Semotilus atromaculatus, Sept.; 2 Ictalurus punctatus, Oct.

Tettiginæ: 1 Ictalurus punctatus, June.

Tettix: 1 Hyodon tergisus, Oct.; 1 Ictalurus punctatus, Oct.

Tettigidea: 1 Lepomis pallidus, June, Nov.

Locustidæ: 1 Lepomis pallidus, May; 2 Semotilus atromaculatus, Sept.

Phaneroptera curvicauda: 1 Lepomis pallidus, Nov.

Nemobius vittatus: 1 Lepomis pallidus, Nov.

Blatta: 1 Ictalurus punctatus, June.

NEUROPTERA.

Larvæ: 2 Roccus chrysops, yg.; 1 Lepomis gibbosus, June; 1 L. pallidus, yg.; 1 Chænobryttus gulosus, yg.; 1 Ambloplites rupestris, yg.; 1 Aphredoderus sayanus, July; 1 Semotilus atromaculatus, May; 2 Hybopsis biguttatus, Aug., Sept.; 1 Phenacobius mirabilis, Oct.; 5 Notropis megalops, May, June; 2 N. whipplei, Apr., July; 1 Moxostoma macrolepidotum, Sept.; 1 Ictiobus velifer; 1 I. cyprinella, July.

Terrestrial: 1 Ictiobus urus, Aug.

Phryganeidæ: 1 Lepomis pallidus, July; 1 Ambloplites rupestris, July; 1 Ictiobus bubalus, Oct.; 1 I. urus, Aug.

Phryganeidæ, larvæ: 2 Perca lutea, May; 2 Etheostoma cœruleum, June; 1 Percina caprodes, Apr.; 2 Lepomis gibbosus, May; 1 L. megalotis, July; 4 Hybopsis biguttatus, Aug., Sept.; 1 Phenacobius mirabilis, Apr.; 3 Notropis atherinoides, July, Aug.; 4 N. megalops, Apr. June; 1 N. stramineus, Apr.; 3 Ictiobus velifer, Aug., Oct.; 5 I. bubalus, Aug., Oct.; 7 Ictalurus punctatus, Apr., May, Aug.; 1 Amiurus nebulosus, May; 1 Noturus gyrinus, May; 3 Polyodon spathula, June, Aug., Sept.

Leptoceridæ, larvæ: 1 Gambusia patruelis, Sept.; 1 Ictalurus punctatus, Oct.

Leptocerus, larvæ: 1 Lepomis gibbosus, July; 1 Ictiobus bubalus, Oct.

Sialidæ, larvæ: 1 Ictiobus cyprinella, July; 1 Ictalurus punctatus, Aug.; 1 Amiurus nebulosus, Oct.; 2 A. mamoratus, Oct.

Sialis infumata: 3 Lepomis pallidus, May, Aug.

Corydalis, larvæ: 1 Lepomis cyanellus, Apr.; 1 Ictiobus cyanellus, Aug.

Corydalis cornutus, larvæ: 1 Pomoxys, Oct.

Odonata, larvæ: 1 Labidesthes sicculus, July; 4 Esox vermiculatus, June, Oct.; 1, 4 in., June; 1 Polyodon spathula, May.

Libellulinæ, larvæ: 4 Aplodinotus grunniens, Sept.; 5 Perca lutea, Mar., May; 2 Lepomis gibbosus, May; 5 L. pallidus, May, Oct.; 1 L. cyanellus, Apr.; 1 yg.; 1 Ambloplites rupestris, July; 1 Pomoxys, May; 1 Aphredoderus sayanus, Oct.; 1 Esox lucius, Aug.; 1 E. vermiculatus, $2\frac{3}{4}$ in., June; 2 Ictiobus bubalus, Aug., Oct.; 1 I. urus, Aug.; 6 Ictalurus punctatus, Mar., Apr., May, Sept.; 2 Amiurus nebulosus, May; 2 Amia calva, May, Aug.

Agrionina, larvæ: 3 Perca lutea, Mar., May; 1 yg.; 1 Hadropterus aspro, Aug.; 2 Micropterus dolomiei, yg.; 1 M. salmoides, Nov.; 2 Lepomis gibbosus, yg.; 3 L. pallidus, May, June, July; 1 yg.; 3 Chænobryttus gulosus, yg.; 1 Ambloplites rupestris, July; 9 Pomoxys, Mar., April, May; 1 Erimyzon sucetta, yg,; 2 Ictalurus punctatus, Mar., Apr.

Agrion, larvæ: 1 Roccus interruptus, May; 1 Labidesthes sicculus, June; 3 Esox vermiculatus, June, July; 1, $2\frac{3}{4}$ in., June; 1 Zygonectes notatus, Sept.; 1 Moxostoma, June; 1 M. macrolepidotum, Aug.; 1 Ictiobus bubalus, Oct.; 2 Ictalurus punctatus, Apr.; 1 Polyodon spathula, May.

Ephemeridæ: 1 Roccus interruptus, May.

Ephemeridæ, larvæ: 1 Aplodinotus grunniens, yg.; 5 Roccus chrysops, Nov.; 2 Perca lutea, May; 3 yg.; 1 Alvarius punctulatus, May; 3 Etheostoma fusiforme, July; 2 E. jessiæ, Sept.; 2 E. cœruleum, July, Aug.; 4 E. lineolatum, Apr., June; 6 Hadropterus aspro, July, Aug.; 5 H. phoxocephalus, Apr., Aug.; 1 Percina caprodes, July, Aug.; 1 Boleosoma camurum; 1 B. maculatum,

Aug.; 2 Ammocrypta pellucida, June; 3 Micropterus dolomiei, yg.; 3 M. salmoides, yg.; 1 Lepomis gibbosus, Aug.; 5 yg.; 2 L. pallidus, July, Aug.; 3 yg.; 1 L. megalotis, July; 3 L. cyanellus, Apr.; 5 yg.; 2 Chænobryttus gulosus, yg.; 2 Ambloplites rupestris, July; 3 Pomoxys, Mar., Apr.; 2 yg.; 2 Centrarchus irideus, July; 1 yg.; 3 Aphredoderus sayanus, July, Sept., Oct.; 2 Fundulus diaphanus, Oct.; 2 Hyodon tergisus, June; 1 Hybopsis biguttatus, June; 3 Notropis atherinoides, Apr., Aug., Oct.; 1 N. megalops, July; 2 N. whipplei, June; 1 N. hudsonius, Aug.; 2 N. stramineus, July; 1 N. heterodon, Sept.; 2 Moxostoma macrolepidotum, Aug., Sept.; 2 Hypentelium nigricans, Aug.; 1 yg.; 3 Ictiobus bubalus, Apr., Oct.; 3 I. urus, June, Aug.; 1 I. cyprinella, July; 13 Ictalurus punctatus, Mar., Apr., May, Aug.; 1, $2\frac{3}{4}$ in., Oct.; 1 Amiurus natalis, $3\frac{1}{2}$ in., Oct.; 1 Amiurus nebulosus, 2 in., Aug.; 1 Noturus, yg.; 6 N. gyrinus, May, Oct.; 1 Amia calva, June; 4 Polyodon spathula, May, June, Aug., Sept.

Cœnis, larvæ: 2 Placopharynx carinatus, Oct.; 5 Hypentelium nigricans, Aug.; 1 Polyodon spathula, May.

Baëtis, larvæ: 1 Lepomis pallidus, June; 1 Ambloplites rupestris, July.

Hexagenia, larvæ: 15 Aplodinotus grunniens, June, Sept., Oct.; 4 yg.; 1 Roccus interruptus, Oct.; 2 R. chrysops, Sept., Oct.; 1 Perca lutea, Oct.; 4 yg.; 1 Hadropterus phoxocephalus, Aug.; 1 Lepomis gibbosus, May; 2 L. pallidus, Nov.; 1 L. cyanellus, Apr.; 2 Chænobryttus gulosus, Oct.; 18 Pomoxys, Mar., Apr., June, July, Oct., Nov.; 3 Aphredoderus sayanus, Sept.; 1 Esox vermiculatus, July; 3 Hyodon tergisus, Aug., Oct.; 1 Notropis megalops, Aug.; 2 N. hudsonius, June, Aug.; 1 Hypentelium nigricans, Aug.; 1 Ictiobus urus, Nov.; 2 I. cyprinella, Aug.; 7 Ictalurus punctatus, Apr., Oct.; 1, 4 in., Sept.; 4 Amiurus natalis, Oct., Nov.; 4 A. nebulosus, May, Oct.; 7 A. marmoratus, Oct., Nov.; 4 Polyodon spathula, May, June, Sept., Nov.

THYSANURA.

Podura: 3 Labidesthes sicculus, Aug., Oct.

ARACHNIDA.

Undetermined: 1 Hyodon tergisus, Oct.

Araneina: 4 Lepomis pallidus, Oct., Nov.; 2 Labidesthes sicculus, June, Oct.; 1 Eucalia inconstans; 3 Zygonectes notatus, June, Oct.; 1 Fundulus diaphanus, Oct.; 1 Dorosoma cepedianum, July; 1 Clupea chrysochloris, $2\frac{1}{4}$ in., Sept.; 1 Hyodon tergisus, Oct.; 1 Notropis atherinoides, Apr.; 1 N. whipplei, Apr.; 1 Ictalurus punctatus, Oct.; 1 Amiurus natalis, Oct.; 2 A. marmoratus, Nov.

Terrestrial Araneina: 3 Labidesthes sicculus, Aug., Oct.

Acarina: 2 Umbra limi, July; 1 Fundulus diaphanus, Oct.; 1 Notemigonus chrysoleucus, July; 1 Notropis megalops, Aug.; 2 N. heterodon, May, July; 1 Ictiobus urus, Aug.; 1 I. cyprinella, Oct.

Hydrachnidæ: 1 Lepomis pallidus, July, Nov.; 5 yg.; 1 Centrarchus irideus, yg.; 1 Labidesthes sicculus, June; 1 Umbra limi, July; 1 Dorosoma cepedianum, July; 2 Moxostoma macrolepidotum, $2\frac{1}{2}$–$2\frac{3}{4}$ in., Aug.; 2 Erimyzon sucetta, yg.; 1 Hypentelium nigricans, yg.; 1 Catostomus teres, Aug.; 1 Ictiobus bubalus, Oct.; 2 I. cyprinella, July; 1 Polyodon spathula, Aug.

Hydrachna: 1 Ambloplites rupestris, July.

Atax: 1 Lepomis pallidus, yg.

CRUSTACEA.

DECAPODA.

Cambarus: 1 Perca lutea, May; 1 Lepomis pallidus, Nov.; 1 L. cyanellus; 2 Ambloplites rupestris, July; 3 Semotilus atromaculatus; 2 Hybopsis biguttatus, Sept., Nov.; 1 Ictiobus urus, Aug.; 3 Ictalurus punctatus, Apr., May, June; 4 Amiurus natalis, May, Aug.; 6 A. nebulosus, May, Aug.; 1, $3\frac{1}{2}$ in., June; 11 Amia calva, Apr., May, June; 1 Lepidosteus platystomus, Apr.

C. virilis: 2 Perca lutea, May; 1 Anguilla rostrata, Aug.; 4 Amia calva, May.

C. propinquus: 3 Lota maculosa, Nov.; 2 Micropterus dolomiei, June.

C. immunis: 1 Micropterus salmoides, Oct.

C. obesus: 1 Amia calva, Apr.

Palæmonetes exilipes: 1 Perca lutea; 1 Lepomis cyanellus; 1 Amiurus natalis, 2 in., July.

AMPHIPODA.

Gammarus, yg.: 2 Alvarius punctulatus.

Gammarus fasciatus: 1 Micropterus dolomiei, yg.

Crangonyx: 1 Alvarius punctulatus, June; 1 Ictiobus cyprinella, July; 1 Amia calva, June.

C. gracilis: 1 Umbra limi, Sept.; 1 Gambusia patruelis, Sept.; 1 Zygonectes notatus, June.

Allorchestes dentata: 1 Roccus interruptus, May; 7 Perca lutea, Mar., May, Aug.; 4 yg,; 1 Percina caprodes, Aug.; 5 Micropterus dolomiei, yg.; 2 Lepomis gibbosus, Aug.; 3 yg.; 8 L. pallidus, May, June, July, Aug.; 1 yg.; 2 L. megalops, June; 1 Ambloplites rupestris, yg.; 1 Centrarchus irideus, yg.; 1 Aphredoderus sayanus, Oct.; 1 Esox vermiculatus, yg.; 6 Fundulus diaphanus, June, Oct.; 1 Notropis megalops, May; 1 N. heterodon, May; 1 Placopharynx carinatus, Oct.; 1 Ictiobus velifer, Oct.; 1 Ictalurus punctatus, May; 1, 4 in., June; 2 Amiurus, yg.; 1 A. natalis, 2½ in., July; 3 A. nebulosus, May; 9 Noturus gyrinus, May, Aug., Oct.; 1 Amia calva, June; 1 Polyodon spathula, May.

ISOPODA.

Asellus: 2 Uranidea richardsoni, Aug.; 1 Aplodinotus grunniens, Apr.; 1 Roccus chrysops; 3 Perca lutea, Mar., Aug.; 1 yg.; 2 Micropterus dolomiei, yg.; 2 Lepomis gibbosus, May, Aug.; 4 L. pallidus, May, Aug.; 1 L. megalotis, June; 1 L. cyanellus, yg.; 2 Aphredoderus sayanus, July, Aug.; 1 Esox vermiculatus, July; 1 Amiurus nebulosus, 3½ in., June; 2 Noturus gyrinus, June, Aug.; 1 Amia calva, June.

Mancasellus tenax: 3 Perca lutea, Mar.; 1 yg.

Entomostraca.

Eggs: 1 Dorosoma cepedianum, Oct.

CLADOCERA.

Daphnella: 1 Percina caprodes, Sept.; 1 Pomoxys, yg.; 1 Notropis heterodon, July; 1 Ictiobus cyprinella, July.

Daphniidæ: 1 Roccus interruptus; yg.; 1 Stizostedion vitreum, yg.; 5 Perca lutea, yg.; 2 Percina caprodes, Aug.; 4 Centrarchinæ, yg.; 1 Micropterus dolomiei, yg.; 4 M. salmoides, yg.; 2 Lepomis gibbosus, yg.; 2 L. pallidus, yg.; 3 L. cyanellus, yg.; 1 Ambloplites rupestris, yg.; 2 Pomoxys, Mar.; 4 yg.; 1 Eucalia inconstans, June; 2 Zygonectes notatus, June; 1 Dorosoma cepedianum, June; 1 Notemigonus chrysoleucus, Sept.; 1 Notropis atherinoides, Oct.; 1 N. whipplei, Aug.; 1 Hypentelium nigricans, yg.; 1 Ictiobus urus, Aug.; 1 Amiurus, yg.; 2 Polyodon spathula, Aug.

Daphniidæ, eggs: 1 Ictiobus urus, Aug.; 1 Polyodon spathula, Aug.

Daphnia: 3 Perca lutea, yg.; 1 Percina caprodes, Aug.; 1 Centrarchinæ, yg.; 2 Chænobryttus gulosus, yg.; 1 Zygonectes notatus, Sept.; 1 Dorosoma cepedianum, $5\frac{1}{4}$ in., Oct.; 3 yg.; 1 Ictiobus velifer, yg.; 1 Ictalurus punctatus, 4 in., June; 1 Amiurus natalis, $2\frac{5}{8}$ in., Oct.; 1 A. nebulosus, $3\frac{1}{2}$ in., June.

Daphnia, eggs: 1 Coregonus artedi.

D. pulex: 1 Perca lutea, yg.; 1 Lepomis pallidus, yg.; 1 Labidesthes sicculus, Aug.; 1 Dorosoma cepedianum, yg.; 2 Notemigonus chrysoleucus, July; 1 Polyodon spathula, June.

D. hyalina: 4 Labidesthes sicculus, June, Aug.

D. retrocurva: 3 Labidesthes sicculus, June.

Simocephalus: 3 Lepomis gibbosus, yg.; 3 L. pallidus, yg.; 3 Chænobryttus gulosus, yg.; 4 Pomoxys, Mar., Apr.; 3 yg.; 2 Notropis heterodon, May, July; 1 Ictiobus velifer, Mar.; 3 Ictiobus urus, Apr., Aug.; 2 I. cyprinella, Apr.; 3 Amiurus, yg.; 2 Notropis gyrinus, Oct.

Simocephalus, eggs: 1 Ictiobus urus, Aug.

S. vetulus: 1 Pomoxys, Mar.

S. americanus: 1 Perca lutea, yg.; 1 Alvarius punctulatus, May; 3 Micropterus salmoides, yg.; 1 Lepomis cyanellus, yg.; 4 Pomoxys, yg.; 1 Centrarchus irideus, yg.; 1 Labidesthes sicculus, Aug.; 1 Esox vermiculatus, yg.; 1 Dorosoma cepedianum, yg.; 1 Ictiobus velifer, Apr.; 2 Amiurus, yg.; 1 A. natalis, $3\frac{1}{2}$ in., Oct.; 1 Amia calva, June; 1 yg.

Ceriodaphnia: 1 Ictiobus urus, Aug.; 1 Amiurus, yg.

C. dentata: 1 Dorosoma cepedianum, yg.

Scapholeberis: 1 Amia calva, yg.

S. mucronatus: 1 Erimyzon sucetta, yg.; 1 Ictiobus velifer, yg.; 2 Amiurus, yg.; 1 A. nebulosus, $3\frac{1}{2}$ in., June; 1 Amia calva, June; 1 Lepidosteus platystomus, yg.

Macrothrix laticornis: 1 Boleosoma maculatum, July; 3 Amiurus, yg.; 2 A. natalis, $2\frac{1}{2}$ in., July.

Bosmina: 2 Perca lutea, yg.; 1 Centrarchinæ, yg.; 4 Lepomis pallidus, May; 2 Chænobryttus gulosus, yg.; 1 Pomoxys, June; 1 yg.; 5 Labidesthes sicculus, June, Aug. Oct.; 1 Eucalia inconstans, June; 1 Coregonus artedi; 1 Dorosoma cepedianum, $5\frac{1}{4}$ in., Oct.; 8 yg.; 1 Cyprinidæ, yg.; 2 Notemigonus chrysoleucus, Sept.; 2 Notropis atherinoides, Nov.; 2 Ictiobus, yg.; 3 I. velifer, Mar., Sept., Oct.; 2 I. bubalus, Oct.; 2 I. urus, Oct.; 4 I. cyprinella, Apr., May, Oct.; 5 Polyodon spathula, May, June, Aug.

B. longirostris: 4 Micropterus salmoides, yg.; 2 Dorosoma cepedianum, yg.; 2 Notropis atherinoides, Oct.

Iliocryptus: 1 Notropis heterodon; July; 1 Ictiobus bubalus, Sept.

Lynceidæ: 1 Perca lutea, yg.; 1 Alvarius punctulatus, May; 1 Chænobryttus gulosus, yg.; 1 Labidesthes sicculus, June; 1 Umbra limi, Sept.; 1 Zygonectes dispar, July; 4 Z. notatus, June, Sept., Oct.; 1 Moxostoma, yg.; 1 M. macrolepidotum, Sept.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 Ictiobus velifer, Oct.; 2 I. bubalus, Sept., Oct.; 3 I. cyprinella, Apr.

Chydorus: 3 Perca lutea, yg.; 4 Alvarius punctulatus, May; 1 Centrarchinæ, yg.; 1 Micropterus salmoides, yg.; 5 Lepomis gibbosus, yg.; 3 L. cyanellus, yg.; 1 Chænobryttus gibbosus; 1 yg.; 8 Pomoxys, yg.; 1 Labidesthes sicculus, Oct.; 6 Eucalia inconstans, June; 1 Esox vermiculatus, yg.; 1 Umbra limi, Sept.; 2 Zygonectes notatus, Sept., Oct.;

2 Fundulus diaphanus, Oct.; 2 Dorosoma cepedianum, yg.; 1 Notemigonus chrysoleucus, Sept.; 2 Notropis atherinoides, Oct.; 1 N. megalops, May; 1 N. whipplei; 5 N. hudsonius, June, July; 10 N. heterodon, May, July, Sept.; 2 Erimyzon sucetta, yg.; 1 Carpiodes, Apr.; 1 Ictiobus urus, Aug.; 2 I. cyprinella, July; 2 Amiurus, yg.; 1 A. nebulosus, May; 1, 2 in., Aug.; 3 Noturus gyrinus, Oct.; 1 Amia calva, June; 1 yg.; 1 Polyodon spathula, May.

C. denticulatus: 1 Pomoxys, yg.

C. spherieus: 1 Coregonus artedi.

Pleuroxus: 1 Perca lutea, yg.; 2 Micropterus salmoides, yg.; 1 Lepomis gibbosus, yg.; 2 L. pallidus, yg.; 2 L. cyanellus, yg.; 1 Chænobryttus gulosus, yg.; 1 Ambloplites rupestris, yg.; 2 Pomoxys, yg.; 1 Labidesthes sicculus, Oct.; 1 Zygonectes notatus, Sept.; 1 Notropis heterodon, Sept.; 4 Moxostoma macrolepidotum, $2\frac{1}{8}$–$2\frac{3}{4}$ in., Aug.; 2 Erimyzon sucetta, yg.; 1 Ictiobus cyprinella, July; 1 Amiurus, yg.; 3 Noturus gyrinus, Oct.

P. dentatus: 1 Lepomis pallidus, yg.; 1 Notropis heterodon, July; 2 Amiurus, yg.

Alona: 1 Lepomis pallidus, Aug.; 3 yg.; 1 Pomoxys, yg.; 1 Centrarchus irideus, yg.; 1 Labidesthes sicculus, Oct.; 3 Umbra limi, Sept.; 3 Fundulus diaphanus, Oct.. 2 Dorosoma cepedianum, July; 1 yg.; 1 Notropis hudsonius, June; 4 N. heterodon, May, July; 1 Moxostoma, yg.; 1 M. macrolepidotum, Sept.; 1 Erimyzon sucetta, yg.; 7 Hypentelium nigricans, yg.; 2 Catostomus teres, June, Aug.; 3 Carpiodes, Apr., July, Oct.; 1 Ictiobus bubalus, Apr.; 2 I. cyprinella, July; 3 Amiurus yg.; 1 Noturus gyrinus, Oct.

Acroperus: 1 Notropis heterodon, May.; 2 Ictiobus cyprinella, July; 3 Amiurus natalis, 2–$2\frac{1}{8}$in., July.

A. leueocephalus: 1 Zygonectes notatus, Oct.; 1 Fundulus diaphanus, Oct.; 1 Notropis megalops, Aug.; 1 N. heterodon, May.

Camptocercus macrurus: 2 Fundulus diaphanus, Oct.

Euryeercus: 1 Pomoxys, yg.; 1 Labidesthes sicculus, June; 1 Fundulus diaphanus, June; 1 Polyodon spathula, May.

Euryeercus lamellatus: 1 Percina caprodes, Aug.; 1 Micropterus salmoides, yg.; 2 Lepomis pallidus, yg.; 1 Amiurus, yg.

Leptodora: 1 Roccus interruptus, yg.; 1 Micropterus salmoides, yg.; 1 Dorosoma cepedianum, yg.; 1 Hyodon tergisus, June; 1 Amiurus nebulosus, Aug.; 1 Polyodon spathula, Aug.

OSTRACODA.

Cypridæ: 1 Stizostedion vitreum, yg.; 1 Alvarius punctulatus; 1 Percina caprodes, Aug.; 1 Centrarchinæ, yg.; 8 Lepomis gibbosus, yg.; 2 L. pallidus, July, Aug.; 2 yg.; 1 L. cyanellus, yg.; 3 Centrarchus irideus, yg.; 1 Notropis heterodon, July; 3 Moxostoma, yg.; 2 M. macrolepidotum, $1\frac{1}{4}$–$2\frac{3}{4}$ in., July, Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 yg.; 1 Hypentelium nigricans, yg.; 4 Carpiodes, Mar., Apr., Aug.; 2 yg.; 2 Ictiobus cyprinella, July; 2 Amiurus, yg.; 3 A. natalis, 2–$2\frac{1}{8}$ in., July.

Cypris: 3 Perca lutea, yg.; 1 Percina caprodes, Aug.; 1 Lepomis pallidus, May; 1 yg.; 1 L. cyanellus, yg.; 1 Pomoxys, Apr.; 1 yg.; 1 Centrarchus irideus, yg.; 2 Aphredoderus sayanus, Sept.; 1 Eucalia inconstans, Oct.; 6 Umbra limi, Sept.; 2 Zygonectes notatus, Sept., Oct.; 3 Fundulus diaphanus, Oct.; 4 Dorosoma cepedianum, Apr., July, Oct.; 1 yg.; 1 Notemigonus chrysoleucus, Sept.; 1 Notropis megalops, Aug.; 4 N. heterodon, May, July, Sept.; 1 Pimephales notatus, Sept.; 1 Moxostoma, yg.; 1 M. macrolepidotum, 2 in., July; 1 Minytrema melanops, Oct.; 1 Catostomus teres, Aug.; 1 Carpiodes, June; 5 Ictiobus bubalus, Apr., Oct.; 3 I. urus, Aug., Oct.; 3 I. cyprinella, Apr., June; 1 Amiurus, yg.; 1 A. natalis, $2\frac{1}{8}$ in., July; 3 Noturus gyrinus, May, Aug.; 2 Polyodon spathula, June, Aug.

C. vidua: 1 Eucalia inconstans; 1 Fundulus diaphanus, Oct.; 2 Notropis hudsonius, July.

Candona: 1 Fundulus diaphanus, Oct.; 1 Noturus gyrinus.

C. bifasciata: 2 Amiurus, yg.

COPEPODA.

Nauplius: 1 Erimyzon sucetta, yg.

Cyclops: 1 Aplodinotus grunniens, yg.; 2 Roccus interruptus, yg.; 7 Perca lutea, yg.; 8 Alvarius punctulatus, May, June;

1 Etheostoma lineolatum, July: 2 Hadropterus aspro, Aug,: 1 Percina caprodes, July; 3 Boleosoma maculatum, July, Aug.; 4 Centrarchinæ, yg.; 1 Micropterus dolomiei, yg.; 8 M. salmoides, yg.; 13 Lepomis pallidus, yg.; 5 L. cyanellus, yg.; 4 Chænobryttus gulosus, yg.; 2 Ambloplites rupestris, yg.; 3 Pomoxys, Apr., June; 15 yg.; 2 Centrarchus irideus, July; 4 yg.; 3 Aphredoderus sayanus, Aug., Sept.; 3 Eucalia inconstans; 1 Gambusia patruelis, Sept.; 2 Zygonectes notatus, Sept., Oct.; 1 Coregonus artedi; 1 Dorosoma cepedianum, July; 1, 5¼ in., Oct.; 10 yg.; 4 Notemigonus chrysoleucus, July, Sept.; 2 Semotilus atromaculatus, July; 1 Phenacobius mirabilis, Sept.; 2 Notropis whipplei, June; 1 N. stramineus, Apr.; 12 N. heterodon, Apr., May, July, Sept.; 1 Moxostoma, yg.; 1 M. macrolepidotum, Sept.; 2, 2½–2¾ in., Aug.; 1 Minytrema melanops, Oct.; 1 Erimyzon sucetta, 1¾ in.; 3 Hypentelium nigricans, yg.; 1 Catostomus teres, June; 8 Carpiodes, Mar., Apr., July, Aug., Oct.; 2 yg.; 10 Ictiobus bubalus, Apr., Sept., Oct.; 1 yg.; 3 I. urus, Apr., Aug., Oct.; 4 I. cyprinella, Apr., June, July; 11 Amiurus, yg.; 2 A. natalis, 2–2⅛ in., July; 2 A. nebulosus, 2–3½ in., June, Aug.; 2 Noturus, yg.; 6 N. gyrinus, Oct.; 1 Amia calva, June; 1 yg.; 3 Polyodon spathula, June, Aug.

C. thomasi: 1 Labidesthes sicculus, Aug.

Canthocamptus: 1 Labidesthes sicculus, Oct.; 1 Notropis stramineus, Apr.; 1 N. heterodon, May; 1 Erimyzon sucetta, 3 in., Oct.; 1 Hypentelium nigricans, yg.; 6 Carpiodes, Mar., Apr., June, Oct.; 1 yg.; 10 Ictiobus bubalus, Apr., Oct.; 1 I. urus, Oct.; 1 I. cyprinella, Oct.; 2 Noturus gyrinus, Oct.; 1 Polyodon spathula, May.

Diaptomus: 1 Perca lutea, yg.; 1 Labidesthes sicculus, Aug.; 1 Notropis atherinoides, Nov.; 1 N. heterodon, July; 1 Amiurus nebulosus, Aug.

Epischura lacustris: 3 Labidesthes sicculus, June, Aug.

Limnocalanus: 1 Labidesthes sicculus, Aug.

VERMES.

Polyzoa: 3 Lepomis pallidus, May, Aug., Oct.; 1 Pomoxys, yg.
Pectinatella magnifica: 1 Lepomis pallidus, yg.; 7 Ictiobus bubalus, Oct.
Plumatella: 1 Placopharynx carinatus, Oct.; 3 Ictiobus bubalus, Oct.; 1 I. cyprinella, Oct.; 2 Ictalurus punctatus, Sept.; 1 Polyodon spathula, May.
Hirudinei: 1 Catostomus teres, Oct.; 3 Ictalurus punctatus, Apr., June; 1 Amiurus nebulosus, May; 5 A. marmoratus, Oct., Nov.; 1 Polyodon spathula, May.
Chætopoda: 1 Aphredoderus sayanus, Sept.
Naididæ: 1 Pimephales promelas, Aug.; 1 Moxostoma macrolepidotum, 2 in., July.
Lumbriculus: 1 Notropis megalops, June.
Lumbricus: 1 Lepomis pallidus, Nov.; 1 yg.
Nematoda: 1 Amiurus nebulosus, Aug.
Gordius: 2 Semotilus atromaculatus, Sept.; 1 Ictalurus punctatus, Oct.
Anguillulidæ: 1 Ictiobus bubalus, Apr.; 1 I. cyprinella, June.
Rotifera: 1 Notropis heterodon, July; 1 Moxostoma, yg.; 3 M. macrolepidotum, $2\frac{1}{8}$–$2\frac{3}{4}$ in., Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 yg.; 2 Catostomus teres, June, Aug.; 1 Carpiodes, yg.; 1 Ictiobus, yg.; 1 I. bubalus, yg.
Anurea: 2 Erimyzon sucetta, yg.; 2 Ictiobus, yg.; 2 I. bubalus, yg.
Brachionus: 1 Ictiobus, yg.
Metopidea: 1 Moxostoma, yg.; 3 M. macrolepidotum, $2\frac{1}{8}$–$2\frac{3}{4}$ in., Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 yg.; 2 Catostomus teres, June, Aug.
Rotifer vulgaris: 1 Catostomus teres, June.
Planaria: 1 Noturus gyrinus, Oct.

PORIFERA.

Spongilla: 2 Ictalurus punctatus, Sept.

PROTOZOA.

Dinobryon: 1 Ictiobus, yg.
Euglena viridis: 4 Notropis, yg.
E. acus: 3 Notropis, yg.
Actinosphærium: 2 Ictiobus, yg.
Centropyxis: 1 Carpiodes, Apr.
C. ecornis: 1 Notropis heterodon, July.
Arcella: 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 2 yg.; 1 Carpiodes, yg.; 1 Ictiobus, yg.
A. discoides: 1 Ictiobus, yg.
A. vulgaris: 1 Ictiobus, yg.
Difflugia: 1 Dorosoma cepedianum, July; 1 Notropis, yg.; 3 N. heterodon, May, July; 1 Pimephales notatus, Aug.; 1 Campostoma anomalum, Aug.; 3 Moxostoma, yg.; 5 M. macrolepidotum, $1\frac{1}{4}$–$2\frac{3}{4}$ in., July, Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 2 yg.; 4 Hypentelium nigricans, yg.; 2 Catostomus teres, June, Aug.; 4 Carpiodes, Apr., Oct.; 1 yg.; 2 Ictiobus urus, Aug., Oct.; 2 I. cyprinella, July; 1 Noturus gyrinus, Oct.
D. globulosa: 1 Gambusia patruelis, Sept.

VEGETABLE FOOD.

Seeds: 3 Fundulus diaphanus, Oct.; 1 Semotilus atromaculatus, July; 1 Notropis atherinoides, July; 2 N. megalops, Apr., Aug.; 6 N. whipplei, Apr., June, Aug.; 3 N. heterodon, May; 1 Moxostoma, yg.; 1 Ictiobus bubalus, Apr.
Corn meal (distillery slops): 1 Dorosoma cepedianum, July; 1 N. whipplei, Aug.; 1 Moxostoma macrolepidotum, Sept.; 3 Ictiobus urus, Oct.; 4 I. cyprinella, Oct.; 2 Ictalurus punctatus, Aug., Oct.; 1 Amiurus nebulosus, Sept.; 1 A. marmoratus, Oct.
Exogenæ: 6 Notropis megalops, June; 1 N. hudsonius, June; 1 Ictalurus punctatus, Apr.
Endogenæ: 1 Micropterus dolomiei, yg.; 3 Notropis megalops, June, July.

Fungi: 3 Notropis, yg.; 1 N. megalops, Aug.; 1 Hybognathus nuchalis, Aug.; 1 Chrosomus erythrogaster, Sept.; 2 Ictiobus, yg.

Terrestrial vegetation: 1 Centrarchinæ, yg.; 1 Pomoxys, Apr.; 1 Esox vermiculatus, June; 1 Hybopsis biguttatus, Sept.; 3 Notropis atherinoides, Apr., May; 4 N. megalops, Apr. Aug.; 3 N. whipplei, Apr., Aug.; 1 N. heterodon, Sept.; 1 Pimephales notatus, Aug.; 1 Ictiobus bubalus, Sept.; 1 I. urus, July; 1 I. cyprinella, June; 4 Ictalurus punctatus, Mar., Apr., Aug.; 1 Amiurus nebulosus, May; 1 Polyodon spathula, May.

Gramineæ, seeds: 2 Notemigonus chrysoleucus, May, Aug.; 7 Hybopsis biguttatus, June, Aug., Sept.; 1 Notropis whipplei, Apr.; 3 N. stramineus, Apr., July; 2 I. bubalus, Apr., Oct.; 1 I. urus, July.

Setaria, seeds: 1 Catostomus teres, Oct.

Aquatic vegetation: 2 Notemigonus chrysoleucus, Aug.; 4 Notropis megalops, Apr., July, Aug.; 3 N. hudsonius, June; 1 Chrosomus erythrogaster, June; 1 Campostoma anomalum, Sept.; 1 Placopharynx carinatus, Oct.; 1 Moxostoma aureolum, Apr.; 2 M. macrolepidotum, May, Sept.; 1 Hypentelium nigricans, Aug.; 5 Carpiodes, July, Oct.; 8 Ictiobus bubalus, Apr., Aug., Oct.; 3 I. urus, July, Oct.; 4 I. cyprinella, Oct.; 4 Ictalurus punctatus, Aug.; 1 Amiurus natalis, $3\frac{1}{2}$ in., Oct.; 1 Amia calva, Aug.; 2 Polyodon spathula, May, June.

AQUATIC PHÆNOGAMIA.

Myriophyllum: 1 Lepomis gibbosus, May.

Ceratophyllum: 1 Lepomis pallidus, May; 2 Pomoxys, Apr., May.; 1 Ictiobus bubalus, Oct.; 1 Amiurus nebulosus, May.

Lemna: 1 Umbra limi, Sept.; 1 Dorosoma cepedianum, July; 1 Placopharynx carinatus, Oct.; 2 Ictiobus bubalus, Oct.; 1 I. urus, Aug.; 1 I. cyprinella, Oct.; 4 Ictalurus punctatus, Sept., Oct.; 1 Amiurus natalis, Oct.

L. trisulca: 1 Pomoxys, May.

L. minor: 1 Ictiobus bubalus, Oct.

Wolffia: 1 Lepomis pallidus, yg.; 1 Aphredoderus sayanus, Sept.; 7 Umbra limi, Sept.; 4 Gambusia patruelis, Sept.; 1 Zygonectes notatus, Sept.; 1 Dorosoma cepedianum, July; 1, $2\frac{1}{2}$ in., July; 1 Placopharynx carinatus, Oct.; 1 Moxostoma macrolepidotum, Sept.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 2 Carpiodes, Oct.; 11 Ictiobus bubalus, Oct.; 2 I. urus, Oct.: 1 Amiurus natalis, Oct.; 2, 2–$2\frac{1}{8}$ in., July.

Naias flexilis: 3 Lepomis pallidus, May, July, Nov.

Potamogeton: 1 Ambloplites rupestris, yg.; 1 Notropis megalops, Apr.; 1 Ictiobus bubalus, Oct.; 3 Ictalurus punctatus, June, Sept.; 1 Amiurus nebulosus, May; 1 A. marmoratus, Oct.; 9 Polyodon spathula, May.

P. gramineus: 2 Ictalurus punctatus, Oct.

AQUATIC CRYPTOGAMIA.

Chara: 1 Lepomis gibbosus, July; 1 Moxostoma macrolepidotum, June; 1 Amiurus nebulosus, July.

Algæ, filamentous: 3 Percina caprodes, Aug.; 2 Lepomis gibbosus, June, Aug.; 1 yg.; 9 L. pallidus, July, Aug., Oct., Nov.; 1 Pomoxys, July; 1 Aphredoderus sayanus, Sept.; 4 Eucalia inconstans, Oct.; 1 Gambusia patruelis, Sept.; 9 Zygonectes notatus, Sept., Oct.; 1 Fundulus diaphanus, Oct.; 2 Dorosoma cepedianum, June, July; 3 Notemigonus chrysoleucus, Aug., Sept.; 4 Semotilus atromaculatus, July; 3 Hybopsis biguttatus, Aug.; 4 Notropis, yg.; 1 N. atherinoides, Aug.; 8 N. megalops, Apr., May, June; 7 N. whipplei, Apr., May, June, Aug.; 7 N. hudsonius, May, June, July; 2 N. heterodon, Apr., May; 3 Pimephales notatus, July, Oct.; 1 Hybognathus nuchalis, May; 2 Chrosomus erythrogaster, Sept.; 7 Campostoma anomalum, Aug., Sept.; 2 Moxostoma, yg.; 1 M. macrolepidotum, Sept.; 1 Erimyzon sucetta, July; 2 Catostomus teres, June, Aug.; 3 Ictiobus bubalus, Aug. Oct.; 3 I. urus, Aug.; 4 I. cyprinella, June, Aug.; 3 Ictalurus punctatus, Oct.; 1 Amiurus nebulosus, May; 1, 2 in., Aug.; 1 Noturus, yg.; 2 N. gyrinus, May; 3 Polyodon spathula, May, June, Aug.

Algæ, unicellular: 1 Dorosoma cepedianum, July; 2 Notropis, yg.; 2 N. whipplei; 1 N. hudsonius, July; 1 Pimephales

promelas, Aug.; 1 Moxostoma, yg.; 1 Ictiobus, yg.; 1 I. bubalus, yg.; 1 I. urus, Aug.; 1 I. cyprinella, Aug.

Cladophora: 4 Ictalurus punctatus, Oct.

C. glomerata: 1 Notropis megalops, June.

Vaucheria: 1 Ictiobus urus, Aug.; 1 Ictalurus punctatus, Aug.

Scenedesmus: 2 Ictiobus cyprinella, Aug.

Protococcus: 1 Dorosoma cepedianum, $2\frac{1}{2}$ in., July; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 Ictiobus bubalus, yg.; 1 I. cyprinella, Aug.

Glœocystis: 1 Notropis whipplei, Apr.

Spirogyra: 1 Semotilus atromaculatus, July; 2 Notropis, yg.; 1 N. whipplei, Apr.

Diatomaceæ: 1 Gambusia patruelis, Sept.: 3 Dorosoma cepedianum, Apr., July; 1, $2\frac{1}{2}$ in., July: 2 Notemigonus chrysoleucus, Aug.: 3 Notropis, yg.: 2 N. megalops, May: 2 N. whipplei, May: 2 N. hudsonius, June, July; 5 N. heterodon, May, July, Sept.: 1 Pimephales notatus, July: 2 Hybognathus nuchalis, May, Sept.: 1 Chrosomus erythrogaster, Sept.: 1 Campostoma anomalum, Sept.: 1 Moxostoma, yg.: 1 Erimyzon sucetta, July; 1 yg.: 5 Hypentelium nigricans, yg.: 1 Catostomus teres, June: 3 Carpiodes, Mar., Sept., Oct.; 2 yg.: 1 Ictiobus bubalus, Aug; 4 I. urus, June, Aug.; 3 I. cyprinella, Apr., Aug.; 1 Amiurus nebulosus, 2 in., Aug; 1 Polyodon spathula, June.

Pinnularia: 1 Gambusia patruelis, Sept.

Pleurosigma: 1 Moxostoma macrolepidotum, $2\frac{3}{8}$ in., Aug.

Cymatopleura: 3 Notropis, yg.

Desmideæ: 1 Notropis megalops, May; 1 Pimephales notatus, Aug.: 2 Moxostoma, yg.: 1 M. macrolepidotum, $2\frac{3}{4}$ in., Aug.

Closterium: 3 Notemigonus chrysoleucus, Sept.; 4 Notropis, yg.; 2 Moxostoma, yg.: 5 M. macrolepidotum, 2–$2\frac{1}{2}$ in., July, Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.: 2 yg.; 2 Hypentelium nigricans, yg.; 2 Catostomus teres, June, Aug.; 1 Ictiobus, yg.; 1 Carpiodes, yg.; 1 Ictiobus bubalus, yg.: 1 I. cyprinella, Aug.

Cosmarium: 4 Notropis, yg.; 1 M. macrolepidotum, $2\frac{3}{4}$ in., Aug.; 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 2 yg.

Staurastrum: 1 Erimyzon sucetta, yg.; 1 Ictiobus cyprinella, Aug.

Nostoc: 2 Ictiobus cyprinella, Aug.; 1 Polyodon spathula, Aug.
Oscillaria: 1 Chrosomus erythrogaster, Sept.; 1 Ictiobus, yg.
Chroöcoccus: 1 Erimyzon sucetta, $1\frac{3}{4}$ in.; 1 yg.

Dirt: 10 Dorosoma cepedianum, Apr., June, July, Oct.; 4, $2\frac{1}{2}$–$5\frac{1}{4}$ in., July, Oct.; 1 Clupea chrysochloris, $1\frac{3}{8}$ in., June; 10 Notemigonus chrysoleucus, July, Aug., Sept.; 3 Hybopsis biguttatus, Aug., Sept.; 2 Phenacobius mirabilis, Sept., Oct.; 1 Notropis hudsonius, May; 1 N. heterodon, Sept.: 8 Pimephales notatus, July, Aug., Sept., Oct.; 4 P. promelas, May, Aug.; 8 Hybognathus nuchalis, May, Aug., Sept., Oct.; 3 Chrosomus erythrogaster, June, Sept.; 9 Campostoma anomalum, Aug., Sept.; 3 Moxostoma, June; 2 M. aureolum, June; 3 M. macrolepidotum, June, Sept.; 2, $2\frac{1}{8}$–$2\frac{3}{4}$ in., Aug.; 1 Minytrema melanops, Sept.; 1 Erimyzon sucetta, July; 6 Carpiodes, Mar., Apr., July, Oct.; 5 Ictiobus urus, Aug.; 1 I. cyprinella, Aug.; 1 Amiurus nebulosus, Sept.